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Some Notes on Highway Construction in France, Germany and England

Observations of an American Engineer During an Inspection Trip in 1927

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PRE-MIXED "Tar Macadam."—The term tar macadam is used quite extensively in England to designate a surface in which the rock is separated into several sizes and each size pre-mixed with a coating of tar at a central mixing plant. The term is also applied to the penetration type of macadam in which tar is used as a binder instead of asphalt.

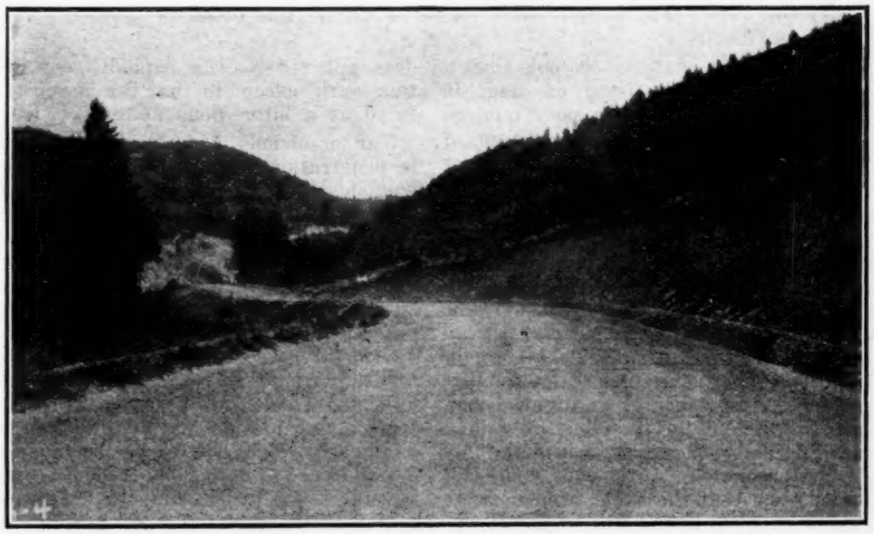


Fig. 2—Nurburg Ring, Germany

Fig. 1 is a closeup of the surface on a main highway in Staffordshire, England. Construction on this section of the road was typical of the pre-mixed tar macadam observed in many localities and its construction is, therefore, of interest. The road consisted of an old tar macadam which had been widened on one side by the construction of a concrete shoulder. Widening is also frequently constructed by using a Telford base and a new macadam surface. The entire roadway is then resurfaced with tar macadam laid in three courses. The first course, 3 in. in thickness, consists of 1½-in. to 2½-in. stone coated with a mixture of tar or of tar asphalt, using about 80 per cent of No. 2 tar and 20 per cent of asphalt. Sufficient tar is used to produce a bright, shiny coating over the rock particles. The tar is heated at the time of mixing but the stone is cold. This material is spread, raked and handled much the same as our bituminous concrete, but without sand or filler appears quite open even after rolling. The second course, 1½ in. thick, consists of tar coated stone from 1½ to ¾ in. in size. This material is also spread cold and the layer thoroughly rolled. The third and last coat is a thin top dressing of ⅝ to ¼ in. tar coated stone chips. It is noted that there is a complete absence of sand and filler in this mix and it might be expected that the surface would be open and porous, also that it might displace as the rock particles crush under traffic and fill the voids. This, apparently, is not the case, as much of this type of construction was observed and there was no evidence of injury due to displacement subsequent to completion. The surface is rather hard and slick in wet weather, but corrugations so familiar to us in bituminous concrete work were entirely absent. Whether this is due to the increased stability resulting from having the rock particles thoroughly interlocked instead of depending on the stability of a mortar filler, or whether it is due to the character of the bitu-

Fig. 1—Closeup of Road Surface in Staffordshire, England

Fig. 3—Experimental Section on Nurburg Race Course

minous binder material is not known. The aggregate consisted of slag, in many cases of a rather poor quality. The photograph shows a close-up of the road surface after the first layer of rock has been spread and rolled.

The inspection trip carried the writer over many miles of construction of this kind before the asphalt concrete type of pavement was encountered. The absence of corrugations and the extreme smoothness of the surface was so noticeable as to suggest that this condition might be due to some difference in method of placing, raking, or compacting under the practice prevailing in England. However, when the hot asphalt concrete work was visited it was found that the same troubles were experienced as in our own work. It was found that the same incipient corrugations and irregularities form in their asphaltic concrete work as in ours and this strongly suggested that the increased smoothness was perhaps due to the absence of the sand mortar and to the placing of the material in three separate courses.

This feeling was later more or less confirmed in a discussion with Mr. Mattimore, materials engineer of Pennsylvania, in which he stated that they have adopted a similar type of construction using asphaltic binder instead of tar and that with these open mixes placed in two or more layers they are securing smoother roads and an apparent increased resistance to displacement. He said that this open mixture was first used on light traveled roads but that the experience seemed to be sufficiently encouraging to justify the use under heavier traffic conditions. In England these open mixtures were used on roads having extremely heavy traffic, both as to loading and volume.

Penetration Tar Macadam.—Penetration tar macadams are used to some extent in most of the three (France, England and Germany) countries visited. The construction of this work does not differ from asphalt penetration work, except in that tar is substituted as a bituminous material.

Tar emulsions have come into use in penetration work as well as asphalt emulsions. The road shown as Fig. 2 is one of the experimental sections on the Nurburg race course in Germany. On this section an 8-in. Telford base was first constructed. The bituminous surface consisted of a penetration macadam in which 2¼ to 2¾ gal. of emulsified tar was used as bituminous binder. Apparently the tar, after the emulsion breaks down, shows the same tendency to harden and become brittle as in cases where hot tar has been used. There was a noticeable tendency to ravel on this work and the engineer stated that more or less continuous patching had been required.

Fig. 3 shows another experimental section on the same race course and the treatment in this case was a standard tar macadam 4 in. in finished thickness. This section appeared much better than the section on which emulsified tar had been used, but it has received one retreatment since its construction less than a year before.

Asphalt Concrete Pavement in England.—Although in England tar macadam predominates as a surfacing over the old macadam foundations, some hot mixed asphaltic concrete has been used and one piece of work of this type was found under construction at the time of this inspection. This work was on the Birmingham-Ipswich Road, Route A-45 in Northamptonshire, England. The work consists of a leveling or binder course from 1½ to 3 in. in thickness. The specifications for this binder course require not less than 6 per cent by weight of bitumen, 12 to 20 per cent of sand, and 74 to 82 per cent of crushed rock from ¼ to 1½ in. in size. This does not differ greatly from leveling courses used in California, except that it contains considerably more bitumen.

The wearing surface specification was as follows:

Bitumen—Not less than 10 per cent by weight.

Sand—30 to 35 per cent by weight.

Aggregate—¼ to ¾ in., 40 to 45 per cent by weight.

This composition differs from our asphaltic concrete wearing surface in that it contains much more bitumen and also in the large amount of filler which is specified as English portland cement. The asphalt in use at the time of inspection was a refined natural asphalt fluxed with a liquid petroleum asphalt. The specification provides that the penetration of the asphalt as used shall be between 45 and 65.

Mixing and laying is conducted in much the same manner as in this country and there was no apparent difference in the quality of the work. It may be that the excess of bitumen in this work is made possible by reason of the cooler climate prevailing in England. This amount of asphalt in a California pavement with the grading given

Fig. 4—View on National Route 20, South of Paris

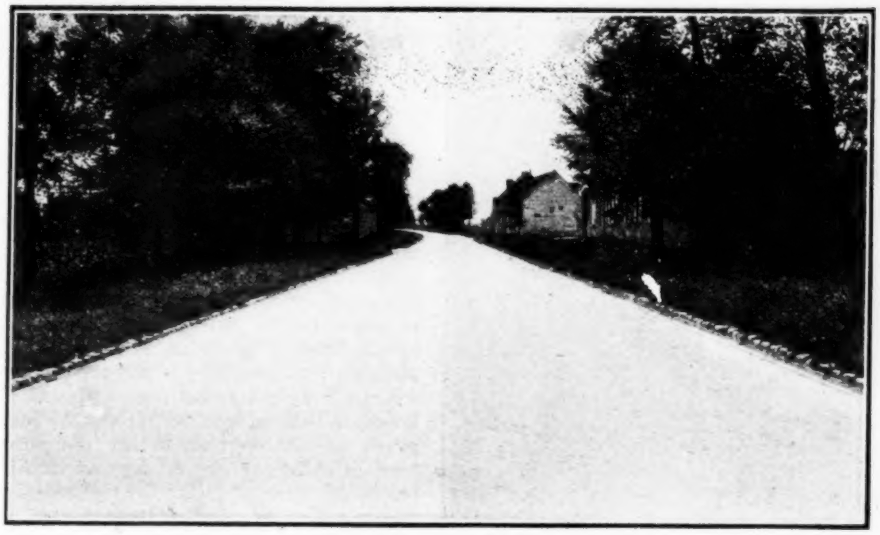


Fig. 5—Asphaltic Concrete on Route 20, South of Paris

would probably result in serious trouble from displacement.

Asphalt Concrete Pavement in France.—About 65 miles of asphaltic concrete pavement was found on Route 20, extending southerly from Paris. This pavement was laid under the trade name of "Monolastic" over an old macadam base. In appearance the pavement suggested a rather wide variation in grading, ranging from sheet asphalt type with occasional rock particles to an asphaltic concrete with a moderate amount of sand. From information obtained from the paving superintendent who was engaged on this construction it was found that Mexican asphalt was used, having a penetration of 45. The material was laid usually over the old macadam, which was previously repaired and brought to a reasonably uniform cross section. On some sections a cement concrete base was laid having a thickness of about 4 in. over the old macadam. A discussion of the methods of proportioning indicated that no fixed gradings were adhered to, but that the gradings were varied by the superintendents in charge to produce what they believed to be the lowest amount of voids and, perhaps, to fit to materials most readily available. The bituminous surfacing was usually laid 2.4 in. loose and rolled to a thickness of about 1.8 in. The writer was informed that the total cost of this surfacing, including the preparation of the macadam, had been about $3.20 per square meter and that the present price for bituminous surfacing alone is about $1.80 per square meter. These prices are greatly in excess of the cost of penetration macadam and surface treatment work, and apparently its use is not being continued on any large scale.

Fig. 4 is a view on national route 20, south of Paris. The pavement is an asphalt concrete surface over old macadam. The asphalt concrete pavement is of the "Monolastic" type. This section closely resembles sheet asphalt in appearance, little or no rock being visible.

Fig. 5 is a view on Route 20, south of Paris (Kilometer 79). This is an unusually satisfactory section of asphaltic concrete, being very smooth and free from waviness and apparently fine sand matrix with rock to 1½ in. There was no flush coat and percentage of rock was probably less than 50 per cent, as rock particles appear rather widely separated in fine sand body of pavement. This texture, however, even on this section varied from heavy to light. The pavement was about two years old at time of inspection.

Plain Concrete Pavement.—The only example of plain concrete which the writer encountered was on the Nurburg Ring (see Fig. 6), a race course in the Eifel Mountains in southern Germany. This race course, 20 miles in length, was entirely new construction and many types of road surfacing were given a trial for the purpose of determining the relative economy.

Fig. 6 is a view of the race cource in front of the grandstand and extending for a distance on either side consists of 8-in. cement concrete laid on earth subgrade. The pavement was laid in alternate 19-ft. panels with no longitudinal joints. In this method the rodding and finishing are done from headers set at the ends of the panels and are, therefore, all longitudinal. The soil is a rather heavy clay. The pavement was a year old at the time of inspection and was in very satisfactory condition. The normal width of the race course is about 25 ft. In front of the grandstand the width was about 50 ft.

Fig. 7, taken on Route A-1, Bedfordshire, England, shows a tar macadam road being widened by the addition of a plain concrete base. Following this the entire width of the roadway will be resurfaced with tar macadam. A granite curb is placed along the edge of the roadway prior to the construction of the tar macadam. The concrete is 8 in. in thickness and approximately 1:2:4 in mix. The old foundation consists of 12 to 18 in. of gravel. This road, locally known as the Great North Road, was originally constructed by the Romans. Traffic is, at times, very heavy. The traffic count at the last Easter time period shows 96,000 vehicles in 48 hours. Trucks loaded to 27 (long) tons net are very common.

Reinforced Concrete.—Fig. 8 is a view on the Birmingham-Ipswich road, Northamptonshire, England. In England it is not unusual to construct a cement concrete base 8 in. in thickness using 1:2:4 mix. This illustration shows a section of pavement which is to be used without a bituminous cover. In reconstructing this highway some line betterments were found desirable and short portions of the highway were relocated. This concrete pavement is on one of the relocated sections and is, therefore, on a new grade. The pavement is 20 ft. in width; 8 in. uniform thickness. The concrete is in two

Fig. 6—Plain Concrete on Nurburg Ring, Germany

Fig. 7—Widening a Tar Macadam Road in Bedfordshire, England

courses. The lower course is a 1:2:4 mix; the upper course, 2 in. in thickness, is 1:1½:3 mix. The upper course follows the lower cource very closely and the two are tamped together. The pavement is reinforced top and bottom with wire mesh reinforcement consisting of 10-gauge wires 5 in. on center in both directions. A high early strength cement known as "Ferro Crete" is used. The pavement is laid in alternate 14-ft. panels. Reinforced concrete beams are constructed transversely under each joint. These beams are about 16 to 18 in. in width. Rodding and finishing is all longitudinal, using the headers as guides in the construction of the first series of panels and using the edges of the panels while filling in between. Great care is taken in placing the upper layer of rich concrete surfacing to prevent forming a plane of cleavage between this and the base course. Concrete is all mixed in a small mixer and transported to the road on mine dump cars. The practice in regard to consistency of concrete would meet the usual standard on high class work in this country. Frequent compressive strength tests are made on specimens moulded from the concrete. This concrete pavement costs $2.64 per square yard, uniform 8 in. thickness. Unit costs are as follows: Sand $2 per ton, gravel $2.85 per ton, and granite $4.60 per ton. Labor receives $0.24 per hour. "Ferro Crete" cement $3.50 per barrell. Except for labor these costs do not differ greatly from those prevailing in the United States. Due to the small amount of equipment used, labor costs are probably relatively higher than they would be for the same work in this country, and this would tend to counterbalance the low unit cost for labor of construction.

Acknowledgment.—The foregoing is abstracted from a paper presented at a meeting of the Western Association of State Highway Officials.

Fig. 8—Constructing Reinforced Concrete Pavement on Birmingham-Ipswich Road, Northamptonshire, England

Applying the Filler

Method Used in Brick Pavement Construction in Ohio

By R. S. BEIGHTLER
Chief Engineer, Ohio State Highway Department

UNTIL about a year ago it was the general practice to completely fill the joints by requiring not less than two applications of the bituminous material. Those of you who have had any experience in the fillin; of brick pavements know that it is absolutely impossible to completely fill the joints with a single application. The contraction due to cooling from 375 degrees or 400 degrees to air temperature is sufficient alone to prevent this result.

Single Application of Fillers.—When a second or third application of the asphalt is made the inevitable result is an appreciable thickness of asphalt film remaining on the surface of the brick. This is extremely objectionable and has resulted in many serious accidents. During the past year a considerable mileage of brick pavements has been laid using a single application of the filler. While there are some engineers who contend that this is not sufficient and insist on having the joints completely filled even at the sacrifice of having excess bitumen on the surface it is believed that if sufficient precaution is taken a satisfactorily filled job may be obtained, even though the brick may not be filled to within ½ in. from the top after coating. It is believed, too, that in most cases after the pavement has gone through the following summer, that an examination of the joints will reveal that they are better filled than they were immediately after the completion of the pavement. This is due to the force of expansion as the pavement is warmed from the sun's rays and thus forcing the filler upward.

Not so many years back lug block with glazed surfaces were used almost exclusively. Excess filler left on the top of the pavement in the operation of filling the joints soon peeled off the smooth glazed surface, leaving the brick exposed and affording proper traction for rubber tires. In recent yeas we have come to use wire-cut lugless brick, the rough side up on all our work. Many engineers continued to insist on the same number of applications and the same quantity of filler on the close joint lugless brick as on the lug brick. The result was a large excess of asphalt which does not wear off the rough wire-cut surface for several years. In the meantime, the traveler, particularly if he comes from afar and is unused to this sort of a surface in wet weather, frequently meets with a serious and sometimes tragic accident. Attempts have been made to overcome this excess of asphalt by spreading

sand or stone chips over the pavement immediately after the application of the filler and rolling with a tandem roller. If the mineral aggregate does not incorporate itself with the excess asphalt, as is often the case due to dampness or the consistency of the asphalt, it is soon whipped off by traffic and the expense entailed goes for naught. If it is incorporated with the asphalt, varying amounts of the excess filler will hold more or less of the sand, thus producing a much rougher pavement than could be otherwise obtained.

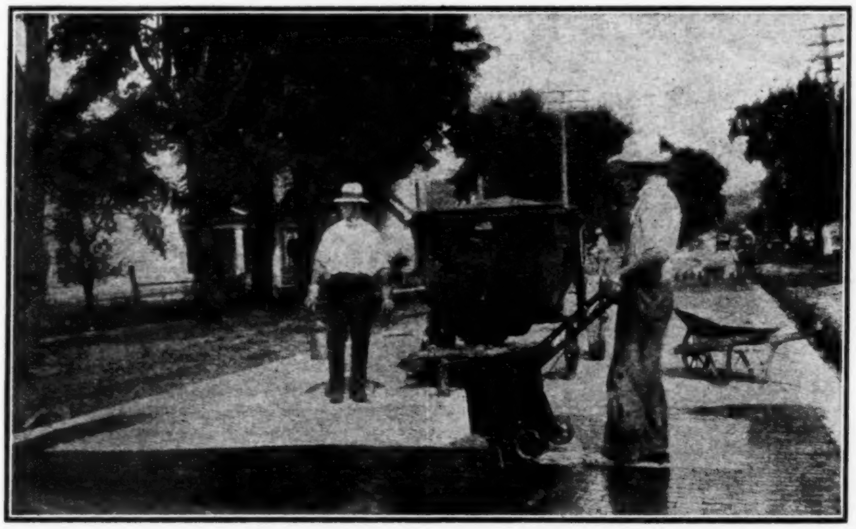
It has been noted that some fillers have a tendency to soften and stick to steel tires. After a quantity of the excess filler has been collected on the tire it falls off creating a very objectionable bump on the pavement.

Method of Application.—We have been able to overcome these difficulties to a large extent by applying the asphalt with what is known as a squeegee bucket or buggy. The hot asphalt instead of being dumped directly onto the pavement is poured into the tank of the machine and is released through a valve at the bottom as needed. It is distributed by means of a rubber and fabric squeegee attached to the machine. It is possible in this way to fill the joints to within ¼ to ½ in. of the top and only leave a very thin film of asphalt on top of the brick. This soon wears off the surface of the brick.

The use of this machine has been encouraged in Ohio and will probably be required in the specifications in the near future.

There seems to be a vast difference in the time it takes various asphalts to become worn off or to chip off the surface of the pavement. This is of course influenced to a large extent by the kind and condition of the brick and the volume of traffic, but even so it seems that under comparable conditions two fillers, both of which meet the specifications, will give widely different results as to the tenacity with which they cling to the surface of the pavement.

An Ohio Experiment.—One experiment which our department conducted during the past year consisted of making one application of our regular asphalt filler designated as bituminous material F-1, following by an application of fluid asphalt cut back—the latter applied cold. This material being a thin fluid does not leave the objectionable film of asphalt on the surface to result in a slippery pavement. We found that such a method filled the joints completely and also tends to soften any adhering hard asphalt filler and in this way serves to retain the sand covering which of course is extremely desirable. We are expecting to carry on further experiments along this line during the coming year.



View of Squeegee Bucket in Operation

Asphalt is released through valve in bottom of bucket manipulated by the operator. Curved squeegee of rubber under bucket scrapes asphalt into joints before it has a chance to cool. The most satisfactory method is to run lengthwise of the pavement next to the curb, as shown, and then fill in remainder by working back and forth. This gives section next to curb, where there are larger cracks, due to batting in, two applications, and the remainder of the pavement one.

This might be helped further by filling the cracks with sand just before applying the cut-back asphalt. This should have a tendency to prevent the thin material from running off and would also give practically a mastic filler for the upper ½ in. which should be beneficial from the standpoint of durability.

Danger of Excess Filler.—An engineer often looks at the construction of a pavement from a standpoint of durability and economy without giving sufficient consideration to the safety and convenience of the traveling public. Excess filler of a particularly tenacious kind has been the cause of 80 automobile accidents on one three-mile stretch of pavement in Ohio. The property damage alone, to say nothing of the attendant suffering and injuries, would have paid many times over for a higher type of filler or more care in applying. It is well enough to say that these accidents were the result of carelessness, but it is beyond the province of the engineer to change human nature; the best he can do is to make the pavement as near fool proof as possible.

The greatest forward step that can be made in the manufacturing and use of asphalt fillers for brick pavements is to prevent, insofar as possible, this excess asphalt on top of the pavement, to furnish an asphalt that will wear off the surface of the brick as quickly as possible and at the same time remain in the joint to keep it permanently sealed. In view of the fact that certain fillers, apparently satisfactory in other respects, disappear from the surface much sooner than others, it is believed that some very helpful work could be done along this line.

Conclusions.—Our experience indicates that we get a much better job of filling where lugged or grooved brick are used and the theory that the plain wire cut brick are more durable does not seem to be borne out as was anticipated. For these reasons Ohio is considering very seriously going back to the old type which will give a wider and more accessible joint.

In conclusion I wish to leave with this body a few ideas for your consideration. I do not mean to submit them as recommendations for some of them are too speculative.

1—The use of lug or grooved brick.

2—When grout filler is used it should be designed with expansion joints at intervals of 50 ft. and along the curb.

3—The use of squeegee buckets in applying asphalt filler and the joints to be filled in one application with hot asphalt to within ½ in. of the top. This operation to be followed by filling the remaining space with sand and final application of asphalt cut back.

Acknowledgment.—The foregoing is abstracted from an article by Mr. Beightler in the June Dependable Highways, the official publication of the National Paving Brick Manufacturers Association.

Where the Maintenance Dollar Goes

An analysis of the 1927 expenditures of the Division of Highways of the California Department of Public Works shows the distribution of the maintenance dollar on highways as follows:

Class of Work—Where Spent:	Cts.
Traveled way	54.5
Roadside	30.7
Improved shoulders	3.0
Structures	6.4
Safety devices	2.0
Drifts	0.6
Trees	1.2
Miscellaneous	1.6
Total	$1.00
Class of Expenditures:	**Cts.**
Labor	44.2
Equipment costs	32.8
Materials	20.6
Service and expense	2.4
Total	$1.00

Capital and Credit

Their Relation to the Contractor

By M. H. CAHILL
President, New York State Bankers' Association

ONE of the most difficult problems with which the banker has to contend is that of teaching the borrower to differentiate between capital and credit.

Credit Easily Destroyed.—Credit is the greatest asset from an economic standpoint in the world, because it is the basic foundation upon which all commercial, industrial and financial activity is carried on. It is, however, a very delicate commodity which can be more easily destroyed than created.

Someone has aptly compared injured credit to a broken piece of beautiful porcelain—you may glue it together again, and it may seem as good as of old, but the cracks are still there and you cannot forget that it was broken.

Credit is based upon confidence—confidence is man's resources and ability to pay; confidence in his character, capacity and integrity; confidence in the stability of the conditions surrounding his business.

Credit making is an opinion of future conditions and of the ability of the contractor to carry out successfully his business contracts. The contractor, therefore, who honestly secures credit is doing so upon the positive assumption of assured future profits which are supposed to result from the current transaction which he is endeavoring to finance.

The entire theory of banking is based upon the proposition that when credit is extended the loan is to be used strictly for a current and temporary transaction from which will be realized profits sufficient in amount to pay off the liability thus incurred, when due.

Capital a Fixed Investment.—Capital is a fixed investment and it should be sufficient in amount to amply care for all necessary fixed assets required in a particular business. As for example: if a man decides to engage in the trucking business because he has secured a contract to haul coal from one point to another at a certain price per ton, his investment in the truck would represent capital and he should have sufficient money of his own to purchase the same. If, however, he wished to borrow money to purchase gasoline and oil to run the truck, this would represent a credit transaction, as the loan would be temporary and he could pay for the same when due out of his profit.

Compare this transaction to the contracting business. In his business, the contractor needs trucks, derricks, steam-shovels, horses and other equipment, all of which cost money. He also needs money to pay the wages of his employees, purchase steel, cement and other material to carry out his construction contract.

Which of these items represent capital and which represent credit? There can be no question as to the proper classification. Only those items which represent temporary investments needed for this particular job can be considered legitimate credit commodities.

The trucks, horses, derricks and other equipment are fixed assets and therefore should represent capital investments, while wages and all material used in the construction work under the contract are properly credit commodities.

Now, the contractor has a perfect right to borrow sufficient money to finance the wages and commodities needed to carry out his contract.

He has, however, absolutely no right whatsoever to borrow one dollar to pay for any of the equipment which he may use on this particular job, but which he will have left as a part of the assets of his company when that job is completed.

The Real Test.—A real test, therefore, for the contractor to apply in this particular case to determine whether or not the money borrowed is credit or capital, assuming, of course, that he has bid in the job on a sound and profitable basis, is to see if he can pay his loan when he receives his profits. If he can, the transaction was a credit transaction; if he cannot, then he borrowed capital which he had no right to do.

Every banker is a trustee because he is dealing with funds which belong to his stockholders and depositors. He is duty bound therefore to exercise due caution and sound judgment when he extends credit. He has no legal or moral right to lend money to any man or corporation unless he has sufficient facts and figures in his hands to justify the honest belief that the loan he makes will be paid when due.

Information to Be Furnished Banker.—This, naturally, brings us to the question, what information should the contractor furnish in order to entitle him to secure credit from his bank.

Generally speaking, he should produce an honest statement of facts and figures showing conclusively:

1. That his business has ample capital for all capital purposes.
2. A profit and loss statement which shows that he is making progress and that his income exceeds in a substantial way his expenses.
3. Facts that will substantiate his belief that the profits he will make in the particular transaction will be more than sufficient to pay the loan when due.

Over and above any of these statements, the contractor, in order to be entitled to consideration for a loan, must have a record of unquestioned integrity and a history of successful achievement in his business endeavors.

Many honest contractors fail with resulting losses to banks because of a lack of ability or sound judgment. In many cases, their desire to overcome unhealthy competition warps their judgment and makes them place unsound bids which result in ruin.

You frequently hear it said, that a contractor has gotten into difficulty and finally failed because of over-expansion of credits. This is just merely another way of saying that he succeeded in getting his banker to lend him capital instead of credit.

Danger Signals.—There are certain danger signals which can be recognized before the loan is made: For example, if a contractor is forced to secure a certified check through a bonding company, it is fairly good evidence that his condition is not sufficiently liquid to provide him with the cash necessary for this purpose. For such a man to undertake a large contract is certainly dangerous, for the reason that there are always certain hazards in this type of business which cannot be figured out with mathematical accuracy when a bid is made. If, therefore, the particular hazard is much more serious than it was estimated to be, and there is not sufficient capital in the company to absorb the resulting loss, that contractor's business is in a precarious condition as he has exhausted his credit and he certainly is not entitled to borrow more to get him out of his difficulty.

Under such circumstances, the contractor may feel that he is being abused because the banker will not accept the fixed assets of his company as security for the loan. If he will just pause a moment and analyze the situation, and appreciate the fact that security is supposed to be liquid to the point where its sale will pay the loan, he can come but to one conclusion, and that is that trucks, derricks, steam-shovels and like equipment are of but little value to the banker as in case of trouble, regardless of their condition, it is difficult to realize much more than junk prices for this type of a commodity.

In conclusion, permit me to say that contractors owe it to themselves and to their bankers to place their business upon as high a standard as possible. It is the banker's business to sell credits and he is always ready and willing to make a loan to any individual or corporation whose character and financial condition warrants the extension of credit.

Furthermore, he is always glad to advise any customer regarding his personal financial problems. If, therefore, every contractor would work closely with his banker and give him only facts, whether they are good or bad, regarding his financial condition and business generally, there would be less failures in the contracting business.

Acknowledgment.—The foregoing is an abstract of an address presented at the third annual convention of the New York State Chapter of the Associated General Contractors.

Bituminous Macadam Construction in Connecticut

Methods Used in Building the Wilton Road

By W. M. CREAMER
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THE purpose of this paper is to present for consideration a few of the methods of construction followed in building the bituminous macadam road connecting the Towns of Westport and Wilton, known as the "Wilton Road." I have divided the subject into several branches, each one of which deals with one particular phase of construction. Believing that no pavement can be satisfactory unless the grading and drainage are properly carried out, I am presenting a few of the steps preceding the work of building the surface courses.

The Project.—The work was let to the L. Suzio Construction Company of Meriden, Conn., and was begun on July 19, 1926. The plan and specifications called for 18 ft. of bituminous macadam; a penetrated top course placed on a 7 in. base course built in two layers, the first 4 in. and the second 3 in. in depth. The crown was 3½ in. and the contour was to follow the arc of a circle, the subgrade being crowned to permit of uniform depth.

The shoulders were to be 4 ft. wide in cuts and 5 ft. wide on fills and the cross-slope was to be 1 in. per foot. Thus the shoulders dropped 4 in. in cuts and 5 in. on fills. Curves were to be banked where their sharpness warranted it and the inside edges were set to the true grade line.

The banks, in cuts, were to be sloped at the rate of 1 ft. vertically to 1½ ft. horizontally, except where ledge rock was expected, in which case the rate of slope was to be 1 ft. vertically to 1/6 ft. horizontally. Embankment slopes were to be built at the rate of 1 ft. vertically to 1½ ft. horizontally.

Where the ledge rock was expected a gravel sub-base 2 ft. in depth, for the full width of the pavement and shoulders, was to be placed, while in certain locations where poor subsoil conditions were expected, a gravel sub-base 1 ft. in depth for the full width of pavement and shoulders was specified.

Construction stakes were driven opposite each 50 ft. station, left and right, marked with a station number, offset to the center line, the center line grade and the amount of bank.

Rough Grading and Drainage.—Corrugated culverts were specified. The first ones installed were directly ahead of the steam shovel. Owing to the fact that operations were begun late in the summer it was decided to try only for a mile of finished surface. In this distance there was only one high fill. Its average height was 8 ft.

At the low point on the ground, beneath this fill, a 24 in. corrugated iron culvert was placed in three 16 ft. sections. The flow-line grade was staked by the inspector and the cut was carried to a depth of 6 in. below this grade for a width of 2 ft. This trench was filled with good clean gravel and the pipe was placed. Care was taken to fasten the collars properly to make tight joints. The gravel made an excellent bearing surface for the entire length of the culvert.

When the cuts were started, the contractor was instructed to take the material out for the full width at the subgrade line, or for a width of 28 ft., and to put the slopes back at such an angle that they would not be ravelled by water action. The reason for this was that we wanted clean stone at all times and, in a partly completed cut, where full shoulders are taken out and where the slopes are left nearly vertical, clean stock-piles of stone cannot be maintained.

All fills were slope staked and we insisted that each one be made in parallel layers not exceeding 2 ft., from the full width at the bottom to the 28 foot width at the top. Fine material was used around the barrels of each pipe and it was tamped into place. All rocks were kept at least 2 ft. from the diameter ends. A shovel was started on July 28, and on Aug. 17 about 3,000 lin. ft. of rough grade was completed from the Wilton end of the project.

Fine Grading. — When the rough grading had been completed for the distance mentioned, fine grading was started and the contractor began setting his grade stakes. These stakes were about 2 ft. long, tapered to a point, and were set opposite each station on the edge of the pavement lines, marked with the grade of the edge of the pavement and the grade of the top of the first layer of the base course. The grade, both in cuts and on fills, was left about 2 in. high during rough grading, so that the material taken out between the stakes was used to form temporary shoulders to bulkhead the thrust of the stone during rolling.

During rough and fine grading the subgrade was kept well drained at all times by the use of temporary ditches. The contractor used a template to lay his fine grade. This template was made of pine and was 1¼ in. thick, by 12 in. wide by 18 ft. long. The bottom was cut to the crown of the road and it was kept in a vertical position by angle irons bolted to each end of the board. Fine grade was kept at least 500 ft. ahead of the first layer of the base course at all times.

Laying the Base Course.—About 600 feet of fine grading had been finished in the manner described, when, on Aug. 21, the contractor began to distribute sand as void filler for both layers of the base course This sand was obtained from a local bank within about a mile haul of the mid-point on the project. The specification for it was "that it should consist of clean hard durable grains, graded from coarse to fine and free from any loam or foreign substances."

Careful inspection was necessary at the point where the sand was loaded. The bank owner did not wish to combine the coarse and fine particles by working the full height of the bank. He was inclined to handle only the lowest lying strata, which was, of course, the finest. The sand was hauled out to the subgrade in 5-ton trucks and was placed in stock-piles about 15 ft. apart. Each stock-pile contained about 2 cu. yd. and was located just beyond the pavement edge.

Payment for sand was made by determining the cubical contents of each truck and converting to weight. Frequent weighings were made on sealed scales in order to find the actual weight of a cubic foot of sand under varying conditions. For this purpose a plant inspector was employed. A careful count of each truck's deposit of sand was kept, and, at night, the contractor's representative and our inspector compared records. The bank owner kept records also and it is interesting to recall how the bank owner and contractor seemed to agree on daily sand output.

On Aug. 30, trap-rock deliveries were begun. The stone was required to meet the following specifications: It was "to be uniformly graded and of such sizes that all will be passed through a screen having circular openings of three inches and be retained on a screen having circular openings of 1½ in." It was furnished to the contractor by the Bertolini Trap-Rock Co. at Bridgeport and

was weighed at the point of loading by our inspector. It was hauled from the quarry in 5-ton trucks and distributed to the subgrade by Burch spreaders to a depth slightly in excess of 4 in. We found it necessary to distribute a depth of 5 in. to obtain the required 4 in. after rolling.

The method employed in keeping track of the stone was as follows: A plant inspector was assigned to the quarry, whose duty it was to keep an accurate record of the weights of all stone as the trucks left for the project. A triplicate form was used, showing date, destination, truck number, contractor's name and the weight of the stone in the truck. This weight was determined by establishing the net and gross weights. The net weight was obtained by weighing the truck empty and the gross weight by weighing the truck loaded. The tare weight (for which payment was computed) was the net subtracted from the gross. Each truck was weighed light once each day. The only weight recorded was the weight of the stone. One of the report forms was kept by our inspector at the plant and two of the forms were carried by the truck driver to the point of distribution on the project. Both of them were given to the inspector in charge of spreading the stone who signed them, giving one to the contractor and keeping one himself. The records of stone delivered on the slips to the road inspector were checked with the records of the plant inspector once each week.

Sand was applied after the first rolling by shovelling from the stock-piles. At first just enough sand was added to fill all the voids. This was rolled by a 10-ton power roller. It was operated from the edge in a direction parallel to the center line. It would make one trip forward and one trip backward, the path going backward overlapping the forward path by about one-half the width of the rear roller wheels until the edge of the inside roller wheel was just over the center line.

After one-half the width had been rolled in this way, the roller man would start at the opposite edge and complete the other half in the same way. Sand was applied, during rolling, until the voids in the path of the roller were completely filled and about ¼-in. surplus remained above the stone. After rolling, the base course was checked by our inspector by means of the template described previously, and all surface irregularities were taken out. If they exceeded 1 in. they were dug out and replaced and, if not, they were scarified and rerolled.

The first and second layers of the base course were put on closely following each other. As soon as about 400 ft. of the first layer was finished, the second layer was begun. In general, as soon as the first layer was sufficiently rolled, the second layer was placed. Owing to the rutting of the first layer, due to truck traffic carrying stone for the second layer, it was necessary to reroll and use additional sand. The second layer was put on and rolled in exactly the same manner except that water was used.

Upon completing the bottom and top layers of the base course the surface again was checked by the inspector. For both layers the roller was kept continually busy, rolling being carried on until the stones were firmly seated. A state of compaction was finally reached when the base course did not yield under one trip of a truck of a total load of 14 tons, this load being the combined weight of truck and stone. For the first layer 16 tons of sand were used to 100 lin. ft., 18 ft. wide. For the second layer, 12 tons of sand were used for the same distance. For the traprock we were using, it required 29 tons to fill 100 lin. ft. for the first layer of the base course, and 22 tons for the second layer. These are average figures.

I wish to call attention to the importance of careful inspection and sufficient rolling when the base course is installed. Filler stone and stone chips were distributed at about the same time that sand was brought out. They were hauled in 5-ton trucks from Bridgeport and stocked just back of the edge of the pavement. The distance between stock-piles was about 12½ ft. and each stock-pile contained about 1 cu. yd. As two sizes, ¾ in. and ½ in. were used, it was not good policy to place these stock-piles too close together. Opposite a pile of ¾ in. stone on the left shoulder, there was placed a pile of ½ in. stone on the right shoulder. The next pile on the left would be ½ in. and the next pile on the right would be ¾ in. stone.

Placing the Top Stone.—On Sept. 18, the base course was completed for about 3,000 lin. ft., and the contractor began bringing out top stone. We had trouble, at first, with the character of some of this stone. Some loads had flat pieces of 3 in. and more. On one day 14 truck loads were rejected because of the presence of dirt. We found it necessary to apply 3½ in. loose to obtain 2½ in. after rolling. The specification for this stone was that "it should all pass a screen having circular openings of 2½ in. in diameter and be retained on a screen having circular openings 1½ in. in diameter." We used about 24 tons of this stone to 100 lin. ft., 18 in. wide. It was rolled until proper surface was obtained and it was then checked by the template. The method of rolling consisted in paths starting at the edge and working to the center. Each area was subjected to the weight of the rollers for two trips.

Application of Bituminous Material and Filler Stone.—On Sept. 22, penetration work began. Five hundred feet of top stone were spread prior to the arrival of the first asphalt truck. Two hundred seventy-five feet were rolled. This asphalt was paid for by the state and was furnished by the Standard Oil Company at Norwalk, being heated, loaded and applied by them.

At 8 A. M. a tank truck of 1,000 gal. capacity, hot, arrived on the job. The application began at 9:10 A. M. and was completed at 9:15 A. M. The gauge of the distributing nozzles was 17 ft. 8 in., center at end to center at end, and there were 36 of them. The overlap was about 2 in. at each edge. The temperature of this application was registered by a thermometer on the tank as 350° F. The roadway covered by this application was 262 ft. According to the specifications we tried, at first, to get an asphalt content of 1¾ cold gallons per square yard. This gave a theoretical consumption of 900 gal. of asphalt to 257 lin. ft. of 18 ft. pavement. Thus our first application showed an over-run of 5 ft., or 1.87 per cent. For the entire length of the project we found the average temperature of application to be 330° F., and it never was below 310. Our average penetrated distance, for the project, was 245 ft. to 900 gal. Thus we actually used 1.84 gal. per square yard, which was within .03 of the mean of the specification. No application was allowed on wet stone.

The filler stone was next spread. It was shovelled from stock-piles which had been placed far in advance of the penetration. Stock-piling filler stone in this way avoids hauling over the top stone which always tends to loosen it and which also disturbs the base course. The specification for this "filler stone" was that "all should pass through a 1 in. circular ring and be retained on a ⅝ in. circular ring." The quantity used was slightly in excess of the amount needed to fill the voids in the surface. This stone was then rolled. We attempted to get an even distribution of the filler stone, and we used about four tons of filler stone to 100 lin. ft., 18 ft. wide. It was not swept.

Application of Seal-Coat and Placing Stone Chips.—The seal-coat was kept as close to the penetration as possible. At times it was necessary to omit it, leaving the first application open for one or two days, as a sufficient portion was not ready for sealing. This application was made at an average temperature of 330° F., and the average number of linear feet covered by each 900 gal. was 530. Thus the actual consumption of asphalt was .85 gal. per square yard, which was within .02 of the mean of the specification. Upon completing this seal-coat application, stone chips were spread. The specification for them was that "all shall pass through a screen having a circular opening ⅝ in. in diameter and be retained on a screen having circular openings of ⅜ in. in diameter." These stone chips were spread by hand from

60 / 2000 153 1/3
180
200

stock-piles formed at the same time the filler stone was brought out. We put on too much, using about 3 tons to 100 lin. ft., 18 in. wide. We had a slight excess above the net amount needed to fill the voids and I believe that this excess was a real detriment. It was carried by traffic to both edges, where it piled up and remained until the shoulders were scraped.

Formation of Laps.—The problem of making laps in a bituminous macadam pavement is not an easy one to solve. We tried three methods. First, "by doing nothing." That is, we allowed the last part of the application to remain as it fell and started the next truck at this point, opening the valve and trusting to God that it would come out right. The results of this practice were not gratifying. We made fatty spots at several joints. We tried digging one out, taking out a strip 4 ft. long and 18 in. wide, replacing the stone and re-applying asphalt. This was our first and last attempt. The rest remain in the road today. Second, —"by troughing." We used two 2x4's, each 18 ft. long, with tar paper, nailed on to form a trough. This was placed over the last foot of each application. The trough was jacked up at one end so it would drain to one side. The truck would back over this trough and the valves would be opened before starting the motor. We found this to be impractical because it was hard to handle. The tar paper became saturated with asphalt after being in use several times and it could not be emptied without spilling the contents over the completed road. This merely transferred our unabsorbed spots. Third,—"by using a hose." A ¾ in. armored hose was attached to the tank by a special valve. The surface ahead of the end of the application was sprayed lightly for about 3 ft. The hose was then removed, the truck was started and at the same time the valve was opened. This method worked best.

About 6,100 lin. ft. of surface was completed during the fall of 1926, and about 9,700 ft. of base course. The base left over the winter received very little truing-up in the spring. It was only necessary to scarify and add sand and stone to those places where depressions had occurred. The contract was completed in June of 1927.

Acknowledgment.—The above is a paper presented at the 1929 meeting of State Highway Inspectors at New Haven, Conn.

High Elevation Roads in Colorado.—Colorado has state roads over Independence Pass, elevation 12,095 ft.; Berthoud Pass, 11,315; Fall River, 11,797; Hoosier, 11,542; Loveland, 11,992; Monarch, 11,650; Fremont, 11,320 and Monarch, 11,650. Driving in the clouds is so common among motorists touring Colorado that it ceased years ago to be a novelty.

Pavement Planning for Future Traffic

The following note is taken from the 6th Biennial Report (biennium ending June 30, 1928) of the Division of Highways of the Department of Public Works of the State of California.

The purpose of the maintenance organization is to serve traffic. To fulfill this obligation the highways must not only be preserved in the best condition, but information as to the rate of development of traffic must be collected so that expansion of transportation facilities will be in advance of traffic needs. With this end in view a special study has been made of the traffic problem during the past two years.

While traffic counts taken each year in January and July provide records of existing traffic, any worthwhile recommendation requires an approximate determination of the traffic capacity of two, three, and four-lane pavements, also an estimate of the probable increase in traffic on any given section of road.

On every heavily traveled road there is a period in the morning and late in the afternoon when travel is heaviest. Analysis of actual hourly records for all sections of the state show that for nearly 90 per cent of the stations the traffic during the peak hour was from 9 per cent to 11 per cent of the total traffic from 6 a. m. to 10 p. m. For practical purposes the peak hour traffic may therefore be accepted as 10 per cent of the 16-hour count.

The next step was to determine the volume of traffic which might use the highway during the peak hour without undue interference. This quantity is influenced by a number of variables, such as condition of the road, alignment, intersections, range in braking distances, percentage of fast and slow vehicles, personal equation of each driver, etc. It is evident, therefore, that any figure adopted must be based on arbitrary assumptions. In making such assumptions in our study, consideration has been given to records of actual performance, experience, and observation.

The planning for pavement width to care for the estimated future traffic requires that the traffic capacity be taken at some definite figure. The range of driving speeds and other factors is so great that practical working capacities vary widely. At the expense of police control, increased danger of accidents and of delay, expense and inconvenience to users of the highways, traffic of 2,000 vehicles per hour may be passed over a single lane roadway at 20 to 25 miles per hour. However, a single vehicle traveling at a speed of two miles per hour would reduce the capacity of our single lane to 330 vehicles per hour. At 50 miles per hour it is theoretically possible to pass 2,400 vehicles per hour over this single lane in the same direction.

Alignment, gradient, proportions of light and heavy traffic, weather, driving conditions, and the personal equation of different drivers all enter into the question of establishing a guide for the proper economical planning of roads for maximum service. These different phases of the problem have been carefully considered in the light of traffic records and actual field conditions, and the following capacities have been arrived at for the purpose of determining the width of pavement necessary to care for the estimated traffic in 1940:

	Vehicles per hour
Two-lane roadway	700
Three-lane roadway	2,000
Four-lane roadway	3,200

These are considered to be the peak hour traffic figures and represent 10 per cent of the traffic for the 16-hour period from 6 a. m. to 10 p. m. This volume of traffic will permit fast traffic to travel at 40 miles per hour and provides for sufficient safe passing space for that purpose. It provides for a safety factor of about 30 per cent, that is, traffic on a two-lane roadway can be increased to 1,000 vehicles per hour without serious delay.

Consideration was also given to rate of traffic increase. This is dependent on increase in population, increase of vehicles in proportion to population, increase in traffic from outside the state, and increased use of vehicles as the highways are improved. For our purposes, after analysis of existing data in the above respect, it seemed reasonable to assume that the increase in traffic would continue at the present rate of nearly 9 per cent annually for the next 12 years without extreme change. Traffic assumptions as of 1940 were worked out on an average of 9.6 per cent annually over the 1926 count.

Oil Surfaced Roads Increase Tire Mileage in New Mexico

Investigation into the economies of oil type surfaced highways by the New Mexico Highway Department has brought to light some interesting facts, advices from New Mexico assert.

It was found out that the motorist on New Mexico roads pays between one-quarter and one-third of a cent per mile of car operation in taxes. In tires alone it has been found, however, that depreciation is from 20 per cent to 30 per cent less on oil type roads than on gravel roads. General car operation is reduced from one to three cents per mile by the higher type roads.

The oil type road does not cut tires as the gravel road does and separation is less on the former type of road. A general decrease in tire depreciation and an increase in mileage is noted on the oil type roads. Data worked up by the Firestone Rubber Co. bears out the statements of the New Mexico Highway Department.

Highway Problems in the Planning of Metropolitan Areas

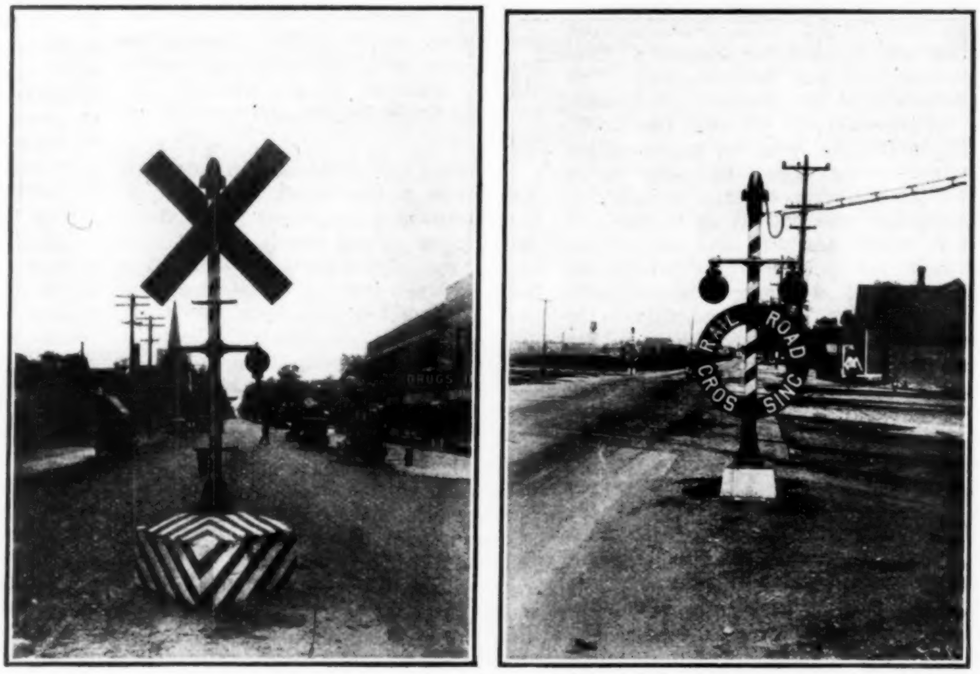
Matching Up Road and Street Plans at Boundary Lines

By ROBERT KINGERY
General Manager, Chicago Regional Planning Association

IN some parts of the country topography is a major problem, but the answer there is readily met by the highway engineers. In metropolitan areas there may be, in addition to the topography, a multiplicity of governing bodies until, as in the case of the region of Chicago, there are almost exactly 1,000 separate municipal and taxing bodies within 50 miles of the Loop. What is true of this region is usually the case in other metropolitan centers, and the examples typical of Chicago may be found elsewhere as well.

Almost everyone in the region of Chicago is planning streets and highways. Of course, there are the officials of the Bureau of Public Roads, the Illinois Division of Highways, the Indiana Highway Commission and the Wisconsin Highway Commission and of each of the 15 different counties which go to make up the region of Chicago, the local improvements boards of the 280 cities, villages and incorporated towns, to say nothing of officers of park districts, forest preserve districts and other municipal organizations, who are empowered by law to plan streets and highways and to construct them. In addition, there is an increasing number of city and village plan commissions and a great many organizations of property owners, commercial interests and others, all of which are planning street and highway extension, relocation and widening.

It is easy to see how there has grown up in the region of Chicago a gigantic picture puzzle, the sections of which are the shapes of the cities and villages and overlying these are similar parts of different shapes, including the park districts, sanitary districts, counties, states and other official jurisdiction. Necessarily, of course, these organizations do not all agree on the points where a street or highway from one area shall meet the street or highway extending into the other area across the invisible boundary line. Commercial interest, community interest, personal interest, all enter into the subject of location and width of streets, highways and boulevards and there is probably no individual out of the 4,900,000 in the region of Chicago who does not have very clear ideas regarding this particular subject and there are comparatively few who do not express these ideas in one form or another.

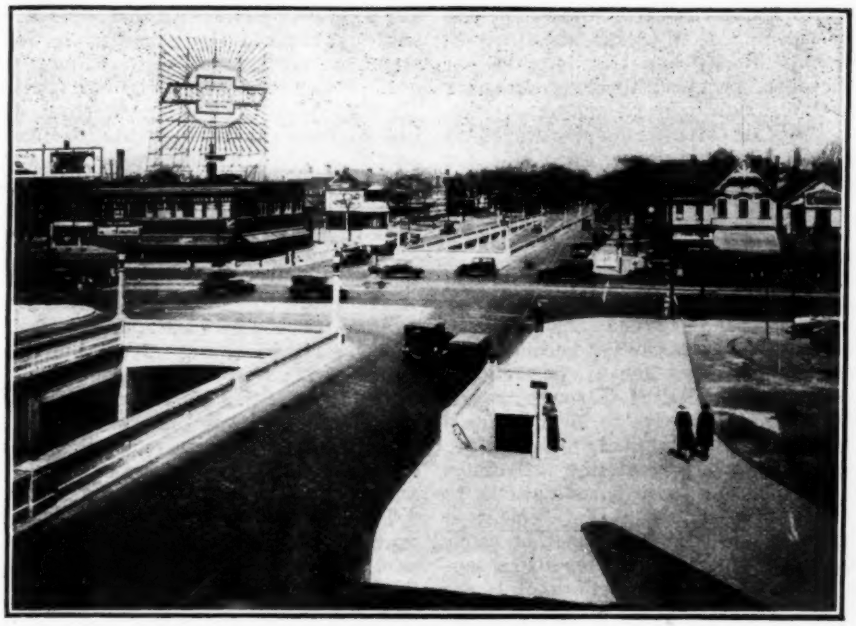


Left—The Center of the Road Is the Wrong Place for a Railroad Grade Crossing Signal. This Installation Is Most Objectionable When the Signal Is Mounted on a Great Block of Concrete. Right—This Is Where the Signal Belongs—at the Side of the Road

Well Planned Systems.—Few states in the Union have better laid out systems of concrete paved highways than have the states of Illinois, Indiana and Wisconsin. It may seem presumptuous for a group of property owners or an organization of commercial interests to attempt to design the state highway system of these three states or those portions of the highway systems which are concentrating on the City of Chicago and its suburban area. Similarly, Cook county is one of the leading counties in the country in the mileage of paved roads and in the soundness of the system which is now being constructed. In Illinois, DuPage, Lake, Kane, Will and other counties in the Chicago metropolitan district are supplementing the statebond issue system by building additional county pavements on state aid roads. In Indiana, Lake, Porter and LaPorte counties, and in Wisconsin, Kenosha, Racine and Walworth counties are constantly perfecting their county systems. The highway officials of these counties have a fund of experience which enables them to design and construct their systems of roads in cooperation with the state highway departments and the Federal Bureau of Public Roads.

Highway Division of Regional Plan.—It has long been evident to these engineers that in some manner all the road and street planning agencies should pool their plans for the purpose of matching them up at the boundary lines of the many different governments. A little more than three years ago they colaborated in forming the highway planning division of the Chicago Regional Planning Association which, when it started active work in 1925 became actually a practical working organization of officials of the principal governments engaged in planning and building roads and streets.

The very fact that there is in existence a common map on which the highway and street building activities



Grade Separation in Detroit. The Center of Grand Boulevard Passes Under E. Jefferson Ave.

are constantly being entered is of help to each of those highway and street planning agencies which contributes to the compilation of this map. In the matter of state highways, evidence has been given at public bearings on the route of such highways so as to have them fit most appropriately into the general scheme that is being developed. Similarly, in the matter of county-built roads, cooperation is given by the committee and staff of the Regional Planning Association to keep out of such a system some of the suggested routes which do not fit into a well considered, well balanced and connected scheme.

County Highway Programs.—Referring specifically to Cook county again, the Regional Planning Association did much of the work of laying out the County Bond Issue System of Highways in a series of meetings with the various public authorities who would build them. These authorities included the State of Illinois, the County of Cook and the several municipalities, including Chicago, all of which are actively taking their share in the program. When the plan was prepared in 1926 it included the widening of 125 miles of old 18- and 20-ft. wide pavement to a width of 40 ft., the construction of 57 miles of City of Chicago street connections 56 ft. wide, the building of 48 miles of new 40-ft. wide pavement outside the city and 250 miles of new 20-ft. wide pavement with shoulders and bridges wide enough to carry future 40-ft. pavements, the widening of pavement at a number of principal highway intersections, and finally the construction of highway grade separations at suitable intersections.

When it comes to detailed surveys of certain of these highways included in the Cook county plan, there again are found a number of interests represented by individuals, property owners' organizations and similar bodies which endeavor to show that a certain alignment for that highway is superior to some other. In one or two proposed routes several surveys have been made, each of which please certain communities and individuals and in rare cases does one of the lines please all. Here again the Board of County Commissioners calls upon the Regional Planning Association for the recommendation of its committee and staff as to the most satisfactory alignment for that particular road and the recommendation of the association is made after due consideration with state and county engineers, of all of the engineering and other features which enter into the designation of that particular route as it relates to all others in its vicinity.

Similarly in DuPage, Will and Lake counties, Illinois, and in Lake, Porter and LaPorte counties of Indiana, cooperation has been given the county and city officials in arriving at general agreement on certain through paved routes which form a region-wide system instead of serving only an extremely local purpose. In Lake county, Indiana, several through pavements have been completed by county and township agencies in the last three years as a result of diligent and successful efforts to bring together the many jealous and discordant interests in the big industrial cities of that area. So, one of the major problems in metropolitan highway construction is to bring together repeatedly the authorities who have the power to act on location and construction of many units of a system of roads and streets.

Recommended Widths of Pavement.—Thirty years ago the average street vehicle required a lane only 7 or 8 ft. wide in which to move with ease and safety. Since then the average street vehicle has been widened, the maximum width being generally 8 ft.; the speed has increased; and they have grown tremendously in numbers. Street and highway authorities throughout the country, that in the metropolitan areas at least, the lane of pavement for moving traffic should be 10 ft., for parking parallel to the curb should be 8 ft. and for diagonal parking 18 ft. in width, the latter dimension convertible into an added lane for moving traffic and a parallel parking lane. These lane widths are considered minimum for safety and free movement of traffic under all conditions of light, darkness, rain, snow, ice and dry weather. They are also considered maximum, because a slightly wider lane invites the crowding in of another car, which is dangerous.

An odd number of lanes for moving traffic on a major street is discouraged. Direction of travel in the center lane is too often in dispute, even when there is some form of traffic regulation, and in the interest of safety in highway design an additional lane should be provided to make an even number.

Applying these unit dimensions to total pavement widths, our highway and city engineers in the region compute the most effective widths at 20, 40 and 60 ft., and street pavement widths 36, 56 and 76 ft. For minor residential streets a lower figure of 26 ft. is recommended, to allow for an 8-ft. parking lane at each curb and one 10-ft. lane for the occasional moving car.

When a state or county highway arrives at the limits of a city the highway pavement widths should be increased by at least 16 ft., and 8-ft. paved parking lane on each side, or the capacity of the pavement is greatly diminished because of the reduction in number of lanes for moving traffic. In this region such standards are set up as the objective, and with increasing success we are persuading municipalities to provide the added width on through streets.

Rights-of-Way and Pavement Width.—Instantly the width of the street right-of-way becomes a problem; in the region of Chicago custom decreed for 100 years a four-rod width (66 ft.) for all streets, when new streets were laid out. In the city of Chicago itself, well over $100,000,000 have been spent on street widening and until less than four years ago the same old mistake of platting all streets uniformly 66 ft. wide was being repeated in the outskirts of Chicago and in the suburban area surrounding.

Needed pavement widths have decreed greater right-of-way widths, a 40-ft. country highway, widened to 56 ft. in the city cannot be placed on a 66-ft. right-of-way and still have adequate space for sidewalks, lamp posts, fire plugs, street trees and all other "street furniture."

Besides the time-honored way of buying right-of-way there are two other methods for obtaining sufficient space for pavement which have been highly successful in this region.

1. By cooperation of subdividers, surveyors, highway engineers, city and county plat officers, a set of rules for the subdivision of land was devised, the principal features of which were: (a) that a uniform procedure was set up for all plats to go through; (b) that the main state and county highways and section line roads should be dedicated not less than 100 ft. in width; (c that the half-section lines and secondary thoroughfares should be not less than 80 ft. in width; (d) that the residential streets should be not less than 66 ft. in width, and, (e) that the alleys where platted should be not less than 20 ft. in width. In less than four years these regulations have been adopted with slight modifications in each of seven different counties in the region of Chicago and in 34 different cities and villages and as a result of their operation nearly 500 miles of 100-ft. wide and 80-ft. wide right-of-way have been dedicated by the subdividers instead of the old 66-ft. width that would have been platted. Incidentally almost 100 miles of 200-ft. wide right-of-way on a system of broad thoroughfares have been similarly dedicated.

2. The second method of acquiring wider rights-of-way is by the establishment of building lines along these thoroughfares, in front of which no new building may be built. In many cases this has been done under police power, by special ordinance, and in some cases setback lines have been established even along main business streets by the zoning ordinances. It has been held by some that the establishment of a building line on private property is illegal because it is depriving the owner of the use of his property without due process of law or without compensation. However, in many cases the building line has been approved in court and a recent decision of the Supreme Court of the United States upholds the building setback line as a sound zoning principle. In the meantime the establishment of building lines by special ordinances or under the zoning ordinance is proving effective in preserving wider spaces between buildings so that a greater part of the publicly-owned right-of-way may be used for traffic purposes. The Regional Planning Association is recommending the establishment of such building lines either by special agreement between the municipality and the property owner, or by special ordinance or resolution which, in the interest of public health, safety and general welfare establishes such a distance between buildings on main traveled thoroughfares.

Highway Widening.—"Highway Widening," or what should properly be called "providing more lanes for moving traffic," may be accomplished in several methods. First study indicates the widening of an existing 20-ft. pavement to 40 ft., and this is a logical procedure, provided there is adequate width of right-of-way and disposition on the part of cities and villages to add the extra lanes on each side for parked cars when the highway enters the city. Even then, however, an undue amount of traffic is thrown onto an already heavy traffic artery.

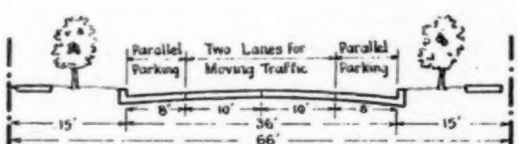
In many cases as good a solution, or better, is to pave a new highway parallel to the old one, and one-half, one or two miles away, because this new route divides the traffic, relieves the high peak load of "through traffic" which is unproductive to local business houses, on the original thoroughfare and affords many of the drivers a shorter distance to their destinations.

Safety, so important an element in the design of highways whether country or metropolitan, dictates also a separation of the two directions of traffic by a neutral strip wherever possible. The one-way drives in Lincoln Park, Logan Boulevard, Garfield Boulevard, Drexel Boulevard and the one on South Parkway, Chicago, are among the heaviest traffic arteries in this region which are freest from accident. Similarly Indianapolis Boulevard, a state highway in Indiana, leading directly into South Chicago, has a singularly clean accident record, although here the two one-way 30-ft.pavements are separated only by crushed stone ballast in the street car track area.

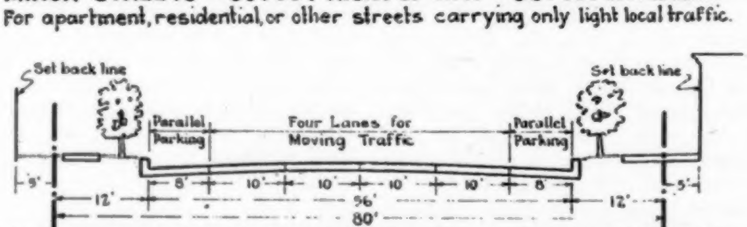
No single standard design of layout can be applied to all cases. Each existing highway in such a metropolitan area has its own characteristics, and each new pavement will take on such character by reason of the use to which the adjacent and nearby property is put. For example, Indianapolis Boulevard, the heaviest traffic artery in the region of Chicago, carries and unusually large relative number of busses and material trucks, so the one-way layout and the extra thick pavement section were designed to meet this situation. Similarly the South Parkway and the Lincoln Park double drives were designed to carry extra fast passenger car and bus traffic with safety.

The Super-Highway.—Popularly the word "super-highway" has come to be used for any highway pavement wider than 20 ft. Properly the word means, and was coined in Michigan to mean just one thing, i. e., a 120-ft. highway separated down the middle by an 84-ft. rapid transit right-of-way, making a total right-of-way width of 204 ft. In the vicinity of Detroit much progress has been made in the actual construction of the highway part of the super-highway, by laying two 44-ft. slabs of pavement, one on each half of the 120-ft. highway right-of-way.

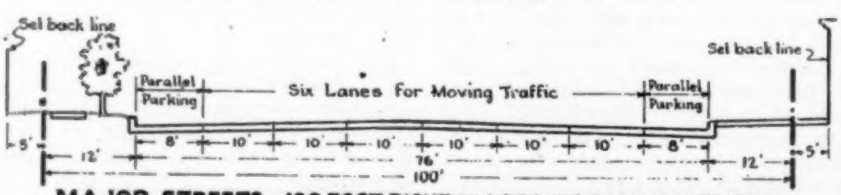
MINOR STREETS – 66 FOOT RIGHT OF WAY – 26 FOOT PAVEMENT
For single family residential streets carrying only light local traffic.



MINOR STREETS – 66 FOOT RIGHT OF WAY – 36 FOOT PAVEMENT
For apartment, residential, or other streets carrying only light local traffic.



MAJOR STREETS – 80 FOOT RIGHT OF WAY – 56 FOOT PAVEMENT
For business or other streets carrying dense traffic.



MAJOR STREETS – 100 FOOT RIGHT OF WAY – 76 FOOT PAVEMENT
For business or other streets carrying very dense traffic.

Recommended Widths of Pavements, Committee on Highways, Chicago Regional Planning Association. An Odd Number of Lanes on a Major Street Is Discouraged

In the region of Chicago high speed rail transportation will not, if it can help it, go onto a public right-of-way, but is purchasing its own private right-of-way. Accordingly, most of our plans for broader highways have been for the boulevard type rather than the super-highway type of cross section. DuPage county, which occupies the same relative position to Chicago as does Westchester county to New York, has pioneered in its establishment of three east and west boulevards, 200 ft. wide all the way across that county. They are located, roughly, six miles apart, two are fairly close to the rows of existing villages which are strung like beads along the Northwestern and the Burlington railroads. On one of these broad rights-of-way a 40-ft. wide concrete pavement was laid by the state of Illinois during 1928.

Since these broad thoroughfares cannot be extended very far east into the more thickly settled part of Cook county it was obvious to the highway authorities that a broad belt highway should be provided as a distributor for the traffic which eventually would be carried on the three DuPage county boulevards, and upon which it could sort itself and enter Chicago or any of the many narrower streets and highways. Accordingly, such a belt line was proposed, and before long it had grown into the plan for a 200-ft. wide right-of-way from the outskirts of Milwaukee around Chicago and to Michigan City, La Porte and South Bend. Passing through three states it was given the name "Three State Boulevard." Some sections of this right-of-way have been located so as to coincide with the location of state or county highways already on the construction program, such as certain state bond issue routes in Illinois, but with no definite assurance of pavement, more than 55 miles of right-of-way 200 ft. wide have been deeded or granted as perpetual easements by the owners of land along this route.

Now it is confidently expected that at least parts of three state bond issue routes in Illinois, 68, 54 and 52, will follow some section of the Three State Boulevard, and thus will be laid the first 20-ft. wide pavement in accord with the final cross section; and that in Indiana the State Highway Commission will build the most needed relief to the Dunes Highway on the Three State right-of-way between one and three miles away; and that in Wisconsin the State Highway Commission will complete a connection with Illinois Route 68 at the state line over this route.

Uniform Traffic Signs and Signals.—Still another highway problem that becomes more acute in a metropolitan area because of the multiplicity of municipal organizations, is the uniformity, or lack of uniformity, of traffic signs and signals. For example, the Harlem Avenue-Waukegan road route, almost a continuous straight line all in Cook county, mostly completed with a 20 or 40-ft. pavement for a distance of 42 miles, lies inside 19 different cities and villages, each of which, plus the state, county, motor clubs, newspaper or other agency, may have its own ideas regarding color, shape and wording of the traffic signs to be installed. Fortunately this pavement is being completed under the state aid plan which gives the state of Illinois jurisdiction over the highway after its completion and acceptance, and because of that fact we may be assured that the signs will be in accord with the standards originally set up by the American Association of State Highway Officials, and since adopted almost intact by all other agencies working toward such uniformity. The street and highway officials of the region of Chicago have directed that we promote the adoption of these standard signs in each of the 280 cities and villages within the metropolitan area, which we have done with some degree of success already. The motor driver should logically expect, and we plan that he soon will be able to receive his instructions as to what to do at the same point above grade, the same distance from his line of travel, and in the same color, shape and wording whether he be in Wheaton, Oak Park, or Chicago, in Kendall or Porter county, or in Indiana, Illinois or Wisconsin.

Uniform Railroad Grade Crossing Signals.—Just as all highway authorities have deplored the past lack of standards in traffic signs, they see the necessity for putting up before the driver a signal he cannot fail to see and recognize as meaning that a train is approaching the grade crossing ahead.

Under an order of the Illinois Commerce Commission two kinds of signals are allowed, the wig-wag and the flashing light types; and two different locations, either in the center or at the side of the roadway. At recent hearings evidence indicated that unanimously the highway authorities favored the side location and objected strongly to the installation of any signal whatever in the center of the roadway, especially those mounted on a great block of concrete. Even the railway signal engineers were about evenly divided between the side and center installations.

As a result of this study, and the consideration of the general problem of railway grade crossings, it seems appropriate to urge that the American Association of State Highway Officials extend its splendid sign and signal work to establish nation-wide standards for type and location of railway grade crossing signals. And it also appears in keeping to suggest that these signals be required on every railroad grade crossing of a marked United States, state or main county highway, that is not protected by gates or flagman. That is our objective in this metropolitan area.

Public Utilities in the Highway.—In metropolitan areas the use of the highway right-of-way becomes more and more intense, not only for pavement and sidewalks but for overhead and underground electric and telephone wires and cables, for gas mains, water mains, sewers, fire plugs, lamp posts, mail boxes and finally, but not least important, trees.

Promptly after the completion of a state or county pavement, almost anywhere in the metropolitan area there is an increase in land values, the abandonment of agriculture and the settlement of the land by population. That population requires water supply and sewage first, then gas, electric light and telephone. And immediately the state or county highway departments must be prepared to allot to each of these utilities a location for their services, and so supervise the construction as to assure the maintenance of traffic, and to protect the pavement from injury and destruction. In the Illinois part of the region of Chicago there has been drafted and put into effect a standard plan for locating these highway facilities, after a series of meetings covering months, first with the public utility engineers and then with the city and village engineers. The resulting specifications and standard locations for these services are "observed" rather than "enforced," principally because those who are affected by them had a part in their preparation.

These same standards for state highway underground construction may readily be extended to county highway work and to the city and village streets not on the main system of thoroughfares, and to that task our organization has already set itself.

Highways to Airports.—Whether or not the important airfields in a region such as this, are served by nearby railroads there must be adequate highway pavement to connect the commercial passenger and mail airports with the downtrown districts. That is obvious without mentioning the consumption of time in air between airports and the time consumed on the ground at the origin or destination.

Separating the grades of two highways is a popular metropolitan problem today. Pavement widening, construction of parallel pavements, separating directions of traffic by a neutral strip, are all relieving greatly the tangles our metropolitan traffic has been enduring, but there are still some intersections which will always carry a dense traffic and cause delay until a separation is built.

Where public land is available, as in a park or a forest preserve, the problem is a simple engineering study, and approaches from one to the other level may be made at each of the four corners. But where right-of-way is even 100 ft. wide, and one or more corners are built upon that problem is intensified. In such a location it is less expensive perhaps, and just as satisfac-

tory to put one thoroughfare all the way down, making a 44-ft. wide tunnel and approach, carry one 20-ft. pavement or wider on the surface at each side next to the sidewalks as the approach to the other pavement. One such separation of country highways is planned and others are contemplated in this region, but examples of city streets and boulevards already completed in this manner are in Detroit at East Jefferson and the Boulevard, and in New York at Fordham Road and Grand Concourse.

While the annual construction of highways in miles and in cost is still lagging behind the annual investment in motor cars and their operation these refinements in highway planning are gaining rapidly. There can be no slackening in quantity of pavement or in number of structures so long as there is no letup in the operation of the rolling stock.

Acknowledgment.—The foregoing paper was presented at the 18th annual Road School of the Wisconsin Highway Commission.

Cost of Grading, Caddo Parish, La.

In the accompanying Table I are presented data on the cost of grading for roads in Caddo Parish, La. These costs are given by J. T. Bullen, Highway Engineer for Caddo Parish, under whose direction the projects listed in the tabulation were carried out. Table II is an outline of the conditions obtaining upon each of the projects furnishing cost figures. All of this work was performed during 1928.

Cost Accounting.—Each foreman is required to send in a detailed daily report of the work performed by his crew, from which the cost accountant's summary by days is made up for each project. As indicated, the total cost is itemized under cost of teams, labor cost, foreman, etc. Foremen are supplied with a plan and a profile of the work, so that the daily yardage and approximate unit-cost for each day may be estimated. Monthly and final estimates are made from actual cross-sections over the finished work. At the completion of a job a recapitulation of costs is made and this, together with the final estimate of yardage, furnishes a final unit-cost for grading over the whole job.

Equipment.—With the exception of the instances where tractors were used, the grading to which these costs apply was performed by fresnoes and mule teams. On the Hosston Miller Bluff Road a Best "60" tractor with a 12-ft. blade was used for "roughing-in" the grade on about one-fourth of the working days. On the Blanchard Furrh Road a McCormick-Deering tractor was used with an 8-ft. blade for plowing and for finishing with a road machine for approximately one-half of the working days. On the Dixie Thanksgiving Road a Best "60" was used with a 12-ft. blade for plowing and finishing.

Rates.—On this work labor was paid 25 ct. an hour. The salary of the foreman was $160 a month. The cost of a tractor and operator was figured at $32.50 a day.

For the cost of mule teams, $1.25 was assumed as a safe figure for one mule for a day. This estimate was made at the beginning of 1928, based upon the 1927 figure of $1.18. The actual cost, as summarized at the close of the year 1928, was $1.15 for one mule for a day. This figure is made up as follows:

Total bills for feed plus 10 per cent for handling by warehouse forces, average for one mule for a day	$0.90
Total bills for shoeing, including salary of blacksmith, his automobile, shoes, nails, etc.	.10
Total cost of hauling feed to camps	.03
Depreciation on mules, wagons, harness, plows and tools	.12
Total	$1.15

Mule maintenance figures are based on 300 actual working days in a year—a figure which has been derived from parish records kept over a period of years.

Table II—Conditions on the Projects

ROAD	SOIL	WEATHER	GENERAL CHARACTER OF GRADING (estimated)	GRADE LINE (est. only)	HAUL (est. only)	SECTION
Lake Shore Drive	50% sandy loam; 50% buckshot clay	Some wet weather but not excessive amount	75% proj. end haul 25% proj. side casting	Approx. av. fill 3.5 ft. Approx. av. fill 1.0 ft.	Av. haul 300 ft. Overhaul 8000 sta-yd. with free haul 500 ft.	26-ft. crown; 2:1 and 4:1 slopes
Thanksgiving Extension	Part sandy loam but majority heavy red clay	Fairly dry period	All easy side casting	Approx. av. fill 2.0 ft.	Side borrow 10% short end haul	26-ft. crown; 4:1 slopes
Hosston Miller Bluff	Some sandy loam but probably half stiff red clay	Fairly dry period	All easy side casting	Approx. av. fill 1.2 ft.	Side borrow 10% end haul	26-ft. crown; 4:1 slopes
Blanchard Furrh	Approx. 50% sandy loam 50% buckshot clay	Some wet weather but not excessive amount	2800 ft. heavy fill 40% proj. cut and fill end haul 60% proj. easy side casting	Approx. av. 5.0 ft. Approx. av. 2.0 ft. Approx. av. fill 1.2 ft.	Side borrow Av. haul 350 ft. Side borrow	26-ft. crown; 2:1 and 4:1 slopes
Dixie Thanksgiving	Some sandy loam but largely heavy red clay	Fairly dry period		Grades from 1.0 to 3.5 ft.		26-ft. crown

Table I—Cost of Grading Per Cubic Yard

ITEM OF COST	PROJECT				
	LAKE SHORE DRIVE	THANKSGIVING EXTENSION	HOSSTON MILLER BLUFF	BLANCHARD FURRH	DIXIE THANKSGIVING
LENGTH OF PROJECT	2.68 mi.	3.35 mi.	3.66 mi.	6.44 mi.	3.63 mi.
QUANTITY MOVED	26,005 c.y.	32,004 c.y.	22,443 c.y.	48,086 c.y.	33,064 c.y.
Teams grading	$0.091	$0.083	$0.076	$0.097	$0.061
Labor grading	0.065	0.063	0.059	0.076	0.043
Tractor and operator			0.035	0.037	0.023
Moving expense	0.003	0.006	0.001	0.002	0.002
Camp expense	0.002	0.003	. . . . .	0.004	0.003
Foreman	0.023	0.021	0.025	0.028	0.016
TOTAL	$0.184	$0.176	$0.196	$0.244	$0.148

Proposed Street Construction in Saloniki, Greece.—The Technical Department of the Municipality of Saloniki has elaborated an extensive program of street construction within the city limits. Many of the streets have not been rebuilt since part of the city was destroyed by fire in 1917. The present scheme includes the construction of 1,500,000 sq. meters of streets with the following materials:

	Square Meters
Asphalt, granite and sand	370,000
Asphalt, macadam	360,000
Granite blocks	110,000
Other granite blocks	100,000
Macadam	560,000

The proposed road construction will involve an expenditure of about $3,000,000. Last year the municipality commenced negotiations for an external loan of $5,000,000, but until this loan has been approved by the National Government of Greece, and the proceeds have been realized, nothing will be done toward the construction of the roads in question. The municipality of Saloniki, however, does not itself intend to undertake the construction of the streets. This work will be given out to existing contractors or to contracting companies that may be formed for that purpose.

Township Road Management in Ontario

Methods of Construction and Maintenance for Minor Roads

By J. H. HAWES
District Municipal Road Engineer, Stratford, Ont.

IN order to secure the most efficient management and the best results in any undertaking, the first essential is the building up of a suitable organization for the administration of the particular project in hand.

This is just as important in the management of township road matters as it is in the operation of larger corporations, in order that the interests of the township and the rate-payers may be safeguarded, and that the greatest possible benefit be derived from the funds at the disposal of the council for the purpose of road improvement.

The organization in most townships upon which the management of township road affairs devolves consists of the township council, the road superintendent, the township engineer, where services of a technical nature are required, and the patrolmen.

A brief outline of the duties of the above officials might be in order at this point.

Duties of Township Council.—To decide on the general program to be followed in the improvement of their roads.

To appropriate the funds for this purpose.

To instruct the clerk to submit to the department early in each year by-laws making the appropriation, with an estimate of the expenditure, and appointing the road superintendent.

To make an annual trip over the roads early in the year in company with the superintendent to decide on the most necessary improvements to be undertaken during the season, and determine where the year's appropriation may be expended to best advantage.

To estimate along with the superintendent as accurately as possible the cost of the various operations to be undertaken, and to adhere as nearly as possible to this estimate. This is necessary in order that they shall not find their funds depleted at the end of the season with a considerable portion of the program uncompleted.

To pass the accounts and paylists presented by the superintendent and order payments by the treasurer.

Duties of Superintendent.—To attend meetings of the council to receive instructions as to work to be undertaken and to report on progress of work in hand.

To supervise construction and repair on roads and bridges under the jurisdiction of the township.

To employ, direct and discharge all men and teams required in the carrying on of the work.

To advise the council of any materials required.

To keep accurate records of the men employed, their time and work performed.

To present pay sheets, accounts and vouchers to the council at specified intervals for their approval, and payment by the treasurer.

To see that all work of a special nature is measured and staked out so that work may be systematically undertaken.

To supervise personally or through a competent inspector all work done by contract, and certify as to its satisfactory completion.

To supervise the opening of snow roads in accordance with such regulations as the council considers necessary.

To arrange for systematic maintenance of the roads through the medium of his patrolmen.

To acquaint himself with the best methods of construction, maintenance, operation of crushers, machinery, etc.

To arrange for the proper care and protection of township machinery when not in use.

And to report to the council at the end of each year, showing in detail the character, location and cost of each separate work undertaken.

Duties of Patrolmen.—These divide themselves naturally into two classes:

1. Works which may be undertaken by the patrolman on his own initiative.
2. Works which are to be undertaken only on special instructions from the superintendent.

In the first class may be cited the following:

(a) Dragging of his beat when necessary.

(b) Seeing that the roadside weeds are cut at the proper time.

(c) Seeing that culverts and ditches are kept free from obstructions.

(d) Minor repairs to culverts and bridges, and filling of holes in the roads.

(e) Opening of snow roads in accordance with the policy laid down in their particular municipality.

(f) Keeping an accurate account of his own time and that of any help employed, and furnishing the same to the superintendent for his approval and recommendation for payment.

When the patrolman himself is unable to undertake any of these duties himself at the proper time, it is his duty to obtain the services of some one who can undertake the work.

In the second class would come such undertakings as the following:

(a) Supervision of any continuous stretch of grading or graveling to which the superintendent is unable to attend personally.

(b) Inspection of new bridge or culvert work.

(c) Any extensive repairs to bridges or culverts.

In fact, the patrolman should not undertake any work of a special nature outside of ordinary routine maintenance without special instructions from the superintendent.

It is of the utmost importance that the various members of the township organization thoroughly acquaint themselves with the duties and limitations pertaining to their respective offices. If this is kept in mind, it will obviate many misunderstandings and duplication of duties among the personnel of the organization.

The council is concerned particularly with the general policy and financing in connection with road matters, while the details of management and the carrying out of their wishes should be left in the hands of the superintendent and his aides. It is the duty of the council, however, to keep in close touch with and well posted on the progress of the work for the protection of the interests of the municipality.

Continuity of Policy Required.—A few suggestions might be in order here with respect to the formulation of a program for the improvement of the township road system in the average township. It is a recognized fact that it is hard to inaugurate a progressive scheme of improvement, extending over a period of years, due to the almost annual change in the personnel of most township councils. However, practically every township has certain roads which stand out in importance as leading market roads, feeders to the county road system or the provincial highway system.

Regardless of changes in the township administration, these particular roads will continue to call for special attention and extra expenditure year after year to cope with the extra traffic which they are called upon to bear. It is always good practice to set aside a definite appropriation year after year for some permanent work in the way of grading and drainage, and the replacement of structures, on these roads. In this way, something of real progress will be accomplished and the maintenance charges will correspondingly de-

crease as the mileage of properly graded and drained roads increases. Thus as time goes on a larger yearly fund will be available for permanent work on the roads and bridges.

The capital of the municipality which is put in to work of a permanent nature such as grading, proper drainage and the replacement of culverts and bridges, may properly be considered as a sound investment from which future benefit will be derived, while expenditures made yearly in placing gravel on improperly prepared subgrades is a never-ending process and nothing tangible in the way of progress is accomplished.

I do not mean that on the completion of a properly constructed gravel road, the problem of maintenance is solved and can be dispensed with, but the saving thus affected is such as to more than warrant the outlay originally made, and expenditures made on future maintenance are in reality merely the protection of an investment already made.

Fixed Charges.—In connection with the annual road program there are certain features which of necessity must be regarded as fixed charges, which must be provided for annually. These include cutting of weeds, superintendence, repair and upkeep of machinery, dragging and patching. These are items which must be provided for every year, and in townships which have been in the system over a period of years, become fairly well standardized and do not vary over a very wide range of cost. From a careful analysis of the cost of such items as above mentioned for a few preceding years, and knowing at the beginning of the season the amounts of funds available for the year, a fairly accurate estimate of the amount which can be devoted to permanent work can be arrived at. With this knowledge at hand, a careful survey of the most urgent locations in need of improvement, throughout the system, should be made and all the surplus that can be provided after allowing for what we have termed fixed charges should be devoted to the purpose. Locations presenting the greatest danger and inconvenience to the users of the roads should receive first consideration, and be attended to in the order of their urgency and just as soon as the finances will permit.

How often one will drive along 2 or 3 miles of road where traveling is comparatively safe, when we will encounter a narrow stretch of cut or fill where it is almost impossible for two vehicles to pass. Strange to say, it is usually at points such as this that we find it necessary to turn out to pass another vehicle. Narrow culverts or bridges, and excessive grades, are other obstacles which should receive the earliest possible attention.

Grading Township Roads.—It is difficult to specify any standard width of grade on township roads. In my opinion, the width of grade should be governed by the importance of the road and the density of the traffic which it is called upon to bear. Possible future development of traffic should be taken into consideration when a new grade is contemplated.

By width of grade, I mean to include the traveled portion of the road and the shoulders, to the line where the grade breaks away to form the ditches on either side. This width should not in any case be less than 20 ft., varying from this up to 24 ft. in the more important roads. This allows for a shoulder of 4 ft. in all cases, and a metalled surface varying from 12 ft. on a 20-ft. grade up to 16 ft. in the case of a 24-ft. grade.

The cross section used for standard grades has been somewhat revised within recent years. Former practices called for a uniform camber for the full width of the grade, the camber employed on metalled surface being continued to the outer edge of the shoulders. From here the grade broke away sharply to the ditch in a slope of one and one-half horizontal to one vertical for ordinary earth. The same slope was employed for the outer or fence side of the ditch. This made a sharp and distinct line of demarcation along the edge of the ditch forming quite a sharp angle with the grade.

More recent practice favors a rounding off of this sharp angle at the edge of the shoulder and the flattening out of the inner slope of the ditch. This, of course, does not apply in heavy fills, where as nearly as possible to a natural slope is employed, to reduce the amount of fill required. Where any pronounced fill is required, the edges of the grade are protected by guard rails. The idea prompting this revision in the cross section of the grade was that it would tend to decrease the seriousness of the results in case where a vehicle accidentally leave the grade. The flattening out of the slope to the ditch will naturally tend to lessen the liability of a vehicle to capsize in the ditch, especially where it is of considerable depth.

The camber employed on the grade varies with the type of road surface to be placed thereon, being reduced to a minimum in the higher types of surface. Modern developments in road making have proved it to be good practice to reduce the camber to a minimum in all cases, only giving sufficient to carry the water from the center of the road to the ditches. The flatter a road can be made, and still accomplish this purpose, the more it contributes to comfort and safety in driving.

In undertaking the grading of a section of road, it should be carefully staked out at the commencement of the work to insure proper alignment and uniform width of grade throughout. Nothing is more unsightly or annoying than to drive on a road wavering from side to side of the right-of-way, when it might just as easily be straight. Care should be taken to provide a continuous fall to a proper outlet in the side ditches. Where it is necessary, borrow earth from the roadside to complete the grade. Care should be taken to avoid the creation of pockets which will collect and hold water along the sides of the road. Sharp curves should be eliminated wherever possible, and extra width provided at important intersections. Attention should also be given to the provision of the best possible vision at intersections and railway crossings to reduce the possibility of accidents at these points.

Permanent Structures.—It is good policy, when possible, to have the culverts built in advance on roads on which grading operations are contemplated. Very few former structures were built sufficiently wide to conform to the present width of newly-constructed grades.

Every user of our highways is aware of the inconvenience and danger attendant on these old narrow structures on grades that have been widened, especially in night driving. They are the source of frequent accidents, and accidents occurring at these points are usually of a serious nature. These structures should be of sufficient width so as not to necessitate any narrowing of the grade on approaching or leaving them. In this way, a grade is made just as safe in crossing culverts as where none exist. On a grade 20 ft. in width, the culverts should have a clear width of roadway of 20 ft. This requires an over-all dimension of 22 ft., allowing for the head walls and wheel guards on our standard type of culvert. Likewise on a 24-ft. grade, the over-all dimension should be made 26 ft.

Care should be exercised in the selection of culvert sites, so as to offer the least possible obstruction to the free flow of the water. They should be located as nearly as possible in the line of flow of the water, quite frequently necessitating the placing of the culvert on a skew with the center line of the road.

Culverts should be of ample proportions to provide for the maximum flow in time of freshets. Practically the only additional cost in adding an extra foot to the span of a culvert is in the floor material, as the side and head-walls, need be varied very little.

Causes of Failures.—Next in importance to proper location and design is the securing of an adequate foundation for the structures. I think it can be conservatively estimated that 50 per cent of the failures in concrete structures throughout the province are directly traceable to insecure foundations. In many cases, the foundation has not been carried down sufficiently to prevent scouring underneath, which will cause ultimate collapse of the culvert.

A careful selection of the materials entering into concrete structures should be made. Many failures can be traced to dirty and inferior sand or gravel going into the aggregate rather than

the lack of cement in the concrete. Good material costs no more to purchase or transport than an inferior quality, and too much caution cannot be used in making the selection.

These structures properly constructed should stand for a lifetime, and inferior workmanship or an unsightly design will remain as an eyesore during the life of the structure. For this reason perfection in workmanship and design should be rigidly insisted upon in all work of a permanent nature.

Gravelling.—Since easily 90 per cent of the material used for the surfacing of township roads is either a natural or artificial gravel, a few observations on the application of this material might be in order.

One of the most vexing problems in many of the townships with which the engineers of the department are confronted is to bring the road authorities to a realization of the proper methods of applying gravel on their roads.

In many cases there is no proper preparation of the grade before the application of new gravel. Often you will find 6 to 9 in. of new gravel applied on a grade which already was too high on the center, making a road that is uncomfortable and unsafe to drive on, in addition to being a waste of valuable material. Much better practice in the case of roads on which gravel has been applied for years would be to scarify the old surface, reshaping it and in the majority of cases reducing the crown. Then by the addition of a light coat, not exceeding 2 in., of fine gravel, a much superior driving surface will result.

The prevailing tendency in almost every instance is the use of too great a quantity rather than insufficient gravel in both first applications and resurfacing operations. An examination of methods employed on our provincial highways and most of our county gravel roads, will disclose the fact that there is rarely to be found more than 2 or 3 in. of compacted gravel on the road surface. Surely if that is found to be adequate on these roads, where the traffic is many times greater both in density and in weight of the vehicles than on township roads, it should not be necessary to use anywhere from 6 to 12 in. of gravel on these minor roads.

It should be borne in mind that the application of gravel to a grade is primarily to provide a smooth wearing crust and a protection to the subgrade from water. The actual carrying power of any road is in the subgrade, not in the surfacing material, be it a gravel surface or a concrete pavement. In cases where a failure occurs in a road, it will almost invariably be found to be due to instability in the subgrade, rather than to a lack of surfacing material.

Conservation of Materials.—There are roads in many townships on which gravel has been consistently applied for 20 years or more. If this old gravel were stirred up, there would be sufficient in many cases, with the addition of a light resurfacing of fine material, to keep the road in first-class condition for years. In this way, funds could be made available for the improvement of the subgrade and drainage.

In my opinion, superintendents who allow a wilful waste of gravel through the application of several times what is needed, are open to just as severe censure as those who may fall short in some other respects. Townships are very fortunate, and very rare indeed, who have a seemingly inexhaustible supply of gravel. It should be constantly kept in mind that the ever-increasing demand for better roads, coupled with the increasing volume of traffic, as time goes on, makes the conservation of our gravel supply a matter of vital impotance. Even at the present time, many localities which a few years ago considered that they had an almost everlasting supply of gravel, are finding their resources in this respect becoming rapidly depleted.

It is found that the spreading of gravel on a road can be accomplished most satisfactorily by the use of the light grader. You get a more uniform distribution of the material than can be secured by hand spreading. It thoroughly mixes the material in case the grade of gravel varies in different loads, and insures a uniformity in the grade of gravel not otherwise obtained.

You can all recall traveling over recently graveled roads where after a couple of weeks' use it is practically possible to count the number of loads that have been dumped by the depression which occurs between each dump. The use of the grader in spreading and in dragging while the gravel is compacting would completely do away with this condition and make traveling much safer and more comfortable.

Best results are always obtained by light and frequent applications of gravel, rather than by putting on a very heavy coat of gravel with the idea that the road will need little or no attention for the next two or three years.

Weed Control.—The control of noxious weeds on the right-of-way is a problem which is coming to be recognized as of more importance from year to year, especially since the passing of the Weed Control Act and amendments. During 1927, a total of $77,675.46 was spent by the townships in weed cutting, and of this amount the province contributed $23,609.88. From these figures it will be realized that quite an honest effort is being made in this direction by the majority of townships, but there is still room for improvement.

It is of prime importance that the weeds be destroyed at the proper times. That is just prior to or immediately on the appearance of the flowers. There is little object in destroying the plants after the flowers have matured and the seeds are ready to be broadcast and bring to life an ever-increasing crop of weeds.

The problem is somewhat simplified where it is possible to operate a mower on the roadside. For this reason we strongly advocated the ploughing and leveling off of the roadsides, where it is made possible by the absence of trees or pole lines. The land thus broken up can then be seeded with some hardy grass, which will tend to smother the weeds and also be profitable as a hay crop to local residents who are willing to take it off. In a few instances, the township has offered to furnish alfalfa seed to residents who will break up and level off the roadsides so that they can be cut with a mower. Those who have taken advantage of the offer have, in most cases, been well repaid for their labor, as well as having protected their farms from contamination by seeds blowing over them from the roadside.

Efficient Patrol System Needed.—The first essential to adequate maintenance is a properly organized and efficient patrol system. It is impossible for the superintendent to attend personally to all the minor details of maintenance. This is especially true in townships where any considerable amount of construction work is going on.

Contrary to the impression which prevails in many townships, this is not an expensive system to put in operation. It is not essential that the individual patrol men spend much of their time or much of the municipal funds on the roads. The object in giving these men supervision over the maintenance of short stretches of road is that they are in a position in the daily execution of their regular duties to keep closely in touch with the maintenance requirements on their beats. They are in a position to apply the stitch in time which is so necessary to keep a road in proper repair, and the saving which will be effected through a properly organized patrol system will more than repay the municipality for any extra expense incurred on this account.

In some instances it may be found necessary to curb the activities of some over-zealous patrol men, but usually, if they are given a clear understanding of their duties, there is no trouble in this respect, and maintenance charges will be found to be considerably curtailed if the patrol organization is functioning properly.

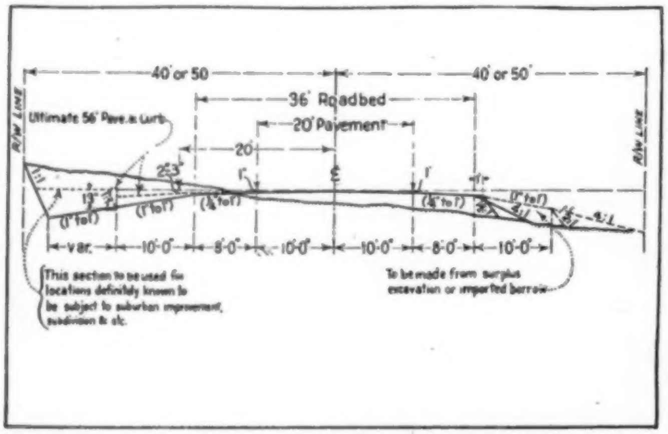
Acknowledgment.—The foregoing paper was presented at the 1929 Conference on Road Construction for County and Township Road Superintendents and Engineers of Ontario.

Typical Road Sections for Various Rights of Way

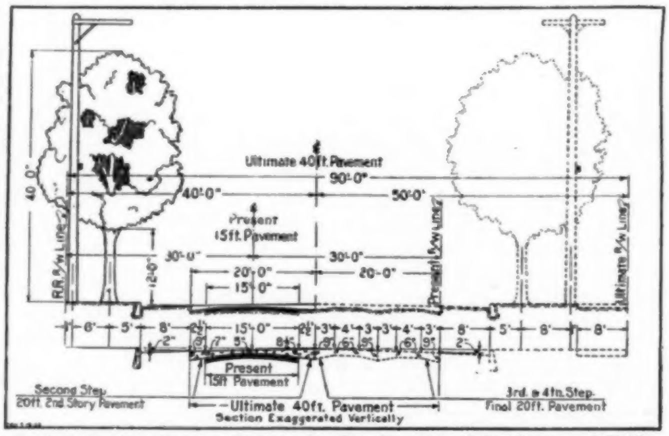
Six Plans Adopted by the California Highway Department

By FRED GRUMM

Engineer of Surveys and Plans, California State Division of Highways



Typical Roadway Grading Section for Use on Valley Roads, Designed to Allow Progressive Development to 56-Ft. Roadbed



Typical Section Showing Progressive Development of Roadway and Utilization of 90-Ft. Right of Way for State Highways Adjacent to Railroad Lines

ADOPTION of standard practice, in so far as possible, for the location upon the right of way of trees, pole lines, and other public utility facilities, is not only desirable but practically imperative if we wish to provide economically for the maximum development and use of the right of way looking toward the greatest service to the traveling public. Realization of this fact led, after considerable study, discussion and conferences, recently, to the adoption of the several typical sections for various widths of right of way.

Six Typical Sections.—These typical sections may be briefly described as follows:

(1) A typical roadway grading section for use on valley roads;

(2) A typical section showing utilization of 80-ft. right of way;

(3) A typical section showing utilization of 100-ft. right of way;

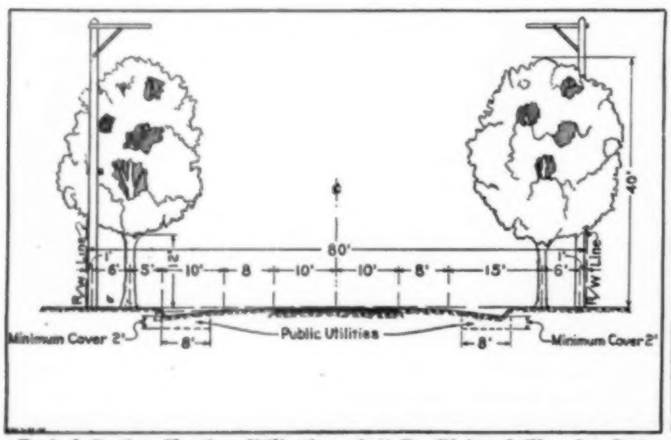
(4) A typical section showing progressive development of roadway and utilization of 90-ft. right of way for state highways adjacent to railroad lines;

(5) Sketch showing plan for development of state highways providing for through traffic and later local traffic as abutting property passes through several stages of use. Minimum development using ultimate 160-ft. or 170-ft. width right of way;

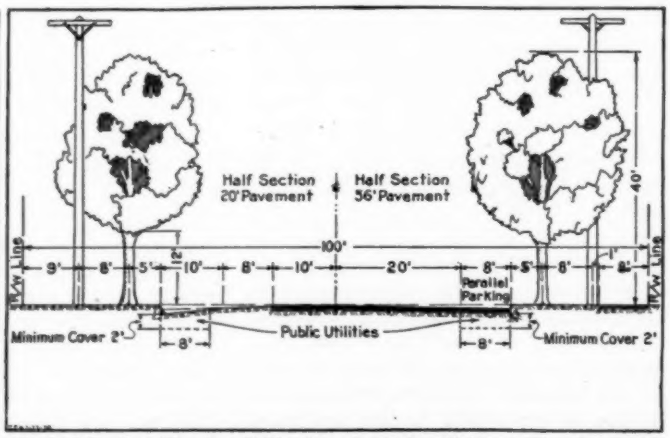
(6) Sketch showing plan for development of state highways providing for through traffic and later local traffic as abutting property passes through several stages of use. Maximum development using ultimate 200-ft. width of right of way.

Grading Section for Valley Roads.—The first, a typical roadway grading section for use on valley roads is so designed as to eliminate borrow pits, substituting therefor a "turnpike section," providing for taking all available excavation material from within the right of way for the construction of the standard 36-ft. width of roadbed and still remaining within the lines and limits of the ultimate 56-ft. development. It is to be used, wherever applicable, in valley or easy country on programmed projects which are being or will be prepared for future improvement. It is particularly applicable to construction and reconstruction projects on routes 3, 4 and 7 in the San Joaquin and Sacramento valleys and on large portions of route 2.

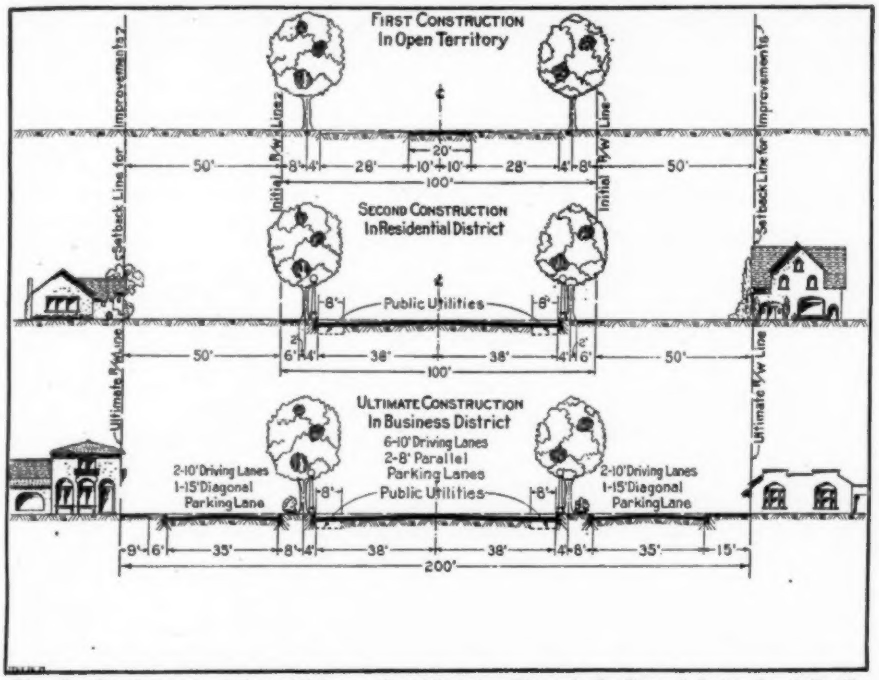
An inspection of a number of the lay-



Typical Section Showing Utilization of 80-Ft. Right of Way for State Highways



Typical Section Showing Utilization of 100-Ft. Right of Way for State Highways



Plan for Development of State Highway, Providing for Through Traffic and Later Local Traffic as Abutting Property Passes Through Several Stages of Use. Maximum Development Using Ultimate 200-Ft. Width Right of Way

out plans and cross-sections in the valley country indicate that: (a) The average cut bank near the right of way line is less than 2 ft; (b) imported borrow is often needed for a 36-ft. roadbed; (c) the full utilization of excavation material within the right of way, as indicated on the section, will usually not result in waste in the construction of a 36-ft. roadbed—in fact often will not make the fills and therefore additional imported borrow is necessary.

The section was developed to make use of all of the excavation within the right of way for the construction of the present 36-ft. roadbed and was designed so that no excavation would be made below the subgrade elevation of the future 56-ft. pavement. Provision is made for taking care of surplus excavation which might develop at certain points. This is to be placed in embankment having slopes similar to those in excavation and to a subgrade elevation for future pavement.

The use of this section in the flat country will provide flat slopes beyond the shoulder of the roadbed, extending in excavation practically to the right of way line, and consequently making this portion of the right of way more easily accessible for maintenance purposes. Where it is definitely known that abutting property is subject to early improvement by subdivision and the construction of business or semibusiness buildings, excavation and embankment can be made, as indicated on the typical section, to provide for placing of curb and sidewalk.

Section for 80-Ft. Right of Way.—The second typical section shows the utilization of 80-ft. right of way. The proper placement of the trees and pole lines is shown which permits of future development of the roadbed to an ultimate 56-ft. width.

Sections for 90-Ft. and 100-Ft. Right of Way.—The third typical section shows the utilization of 100-ft. right of way, on which is indicated the location of trees, pole lines, and sidewalks. This section is also designed to permit the construction of an ultimate 56-ft. pavement.

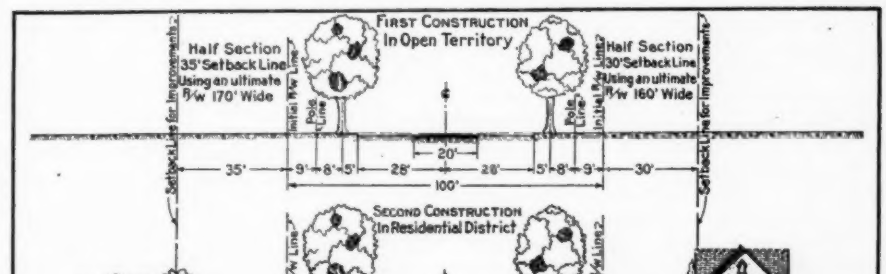
The fourth typical section shows the utilization of 90-ft. right of way for state highways adjacent to railroad lines. It has been primarily designed to care for the reconstruction and widening of our present narrow pavements in such locations, looking toward ultimate future development of the 56-ft. width in a progressive manner without incurring the loss or reconstruction of the first stages of the work. It embodies the idea of sloping the 20-ft. pavement, undertaken as the first reconstruction step, in one direction, permitting the addition of future widening without disturbing this original construction.

It is obvious that this method of development preserves the original 15-ft. pavement without loss, permits the addition of resurfacing where flush shoulders have been constructed on the old 15-ft. pavements, permits the second and third step of development without loss of previous installation or thickening of the same with the attending necessity of continually raising the grade.

Since on the railroad side no development of property is possible, sidewalk space has been omitted, and only sufficient space between the ultimate curb line and the right of way line is provided to place trees and poles. On the opposite side away from the railroad right of way, the same space is provided as on the typical section for the 100-ft. width of right of way.

Plan for 56-Ft. Traffic Width.—The fifth typical section shows a plan for developing the state highway to an ultimate 56-ft. width for through traffic, and by use of setback lines to provide for the later construction of side roads or local service lanes as the abutting property develops.

This plan shows two half-width sections; one for an ultimate 160-ft. right



Plan for Development of State Highways Providing for Through Traffic and Later Local Traffic as Abutting Property Passes Through Several Stages of Use. Minimum Development Using Ultimate 160-Ft. or 170-Ft. Width of Right of Way

of way, the other for an ultimate 170-ft. right of way. The difference between the two being in the width of the side road or local service lane, which on the 160-ft. right of way is 30 ft. in width, consisting of two 10-ft. driving lanes, and one 8-ft. parallel parking lane, and on the 170-ft. right of way of a 35-ft. side road or local service lane, consisting of two 10-ft. driving lanes, and one 15-ft. diagonal parking lane.

The ultimate development as shown provides a 56-ft. width for through traffic, designed on the basis of four 10-ft. driving lanes, and two 8-ft. parallel parking lanes, with the local service lanes, previously described, separated from this through traffic road by parking strips 12 ft. in width on which trees and light standards may be placed. It is to be noted that trees which may have been planted during the first construction, will remain undisturbed in the progressive development to the ultimate construction. This section may be considered the minimum development in territory which may be improved and become a business district.

Plan for 76-Ft. Width.—The sixth typical section shows a plan for developing state highways to an ultimate 76-ft. width. This is accomplished by establishing 50-ft. setback lines from the original 100-ft. right of way. This width will provide, in the future when abutting property develops into a business district, for a 76-ft. road for through traffic, consisting of six 10-ft. driving lanes and two 8-ft. parallel parking lanes and local service roads on each side, 35 ft. in width, consisting each of two 10-ft. driving lanes and one 15-ft. diagonal parking lane. These local service roads are separated from the through road, as in the previous section, by 12-ft. parking strips.

This last section may be considered the maximum development and probably will apply only to a small mileage of the state highway system.

The various features outside of the roadway section surfacing or pavement, such as the various public utility facilities, pole lines, trees, etc., are placed upon the right of way under permits issued by the Division of Highways. These typical sections indicate the definite location for these various features and will provide that their installation under permit in the future will insure not only sufficient room for the development of our proper roadbed section, but will also obviate the necessity for their removal whenever widening or improvement of the road is undertaken.

The adoption of these definite sections permits the carrying out of a well formed policy relative to stage construction of the highway in an orderly, economical, progressive development keeping pace with the traffic requirements and leading to the ultimate development therein illustrated.

Acknowledgment.—The foregoing is taken from the May-June California Highways and Public Works, the official publication of the Division of Highways of the Department of Public Works of California.

Early Completion of Pan American Highway Urged

One of the major projects urged before the second Pan American Highway Congress at Rio de Janeiro in August by the United States delegation will be immediate action toward early completion of the Pan American highway to link the farthest reaches of the northern and southern Americas.

President Hoover has named to represent this country in Brazil a group particularly well equipped to interpret road building progress in the United States to the Latin nations.

Major Frederic A. Reimer, East Orange, N. J., President of the American Road Builders' Association and a consulting civil engineer by profession, brings to the commission a wealth of experience in highway affairs of his native state. Nationally, he has held active membership in the road builders' organization for 15 years and was a director and member of its executive committee before his elevation to the presidency.

Charles M. Babcock, St. Paul, Minn., Commissioner of highways of that state, a past president of the American Road Builders' Association and present member of its executive and highway finance committees, has played a prominent part in state and national road building progress for many years. He was named as a representative of the United States to the first Pan American Highway Conference in 1925.

From Congress, President Hoover selected Senator Tasker L. Oddie, Nevada, member of the Senate post office and post roads committee, and Representative Cyrenus Cole, Iowa. Thomas H. MacDonald, Chief of the U. S. Bureau of Public Roads; Frank T. Sheets, Chief Highway Engineer of Illinois; H. H. Rice, Detroit, Treasurer and Director, National Automobile Chamber of Commerce; and J. Walter Drake, Detroit, former assistant Secretary of Commerce, who will be chairman, complete the delegation.

As official representatives of the President, the group will be formally welcomed to the Brazillian meeting which opens August 16. After the ten days of conference sessions, with many spectacular entertainment features to complement the study of all phases of road building throughout the Western hemisphere, the United States group will study road developments in Uruguay, Argentina, Chile and Peru before returning to the United States in November.

Everywhere they will find a warm welcome, owing to the friendly feeling created by President-elect Hoover's South American tour last year. The President's observations of road building needs of those countries have kindled a great interest in the subject both in South America and the United States.

During the tour, the American Road Builders' Association officials will confer with that organization's honorary representatives, of which there are several in each of the twenty-one South and Central American nations. These honorary representatives comprise the Pan American division, headed by Senor Octavio Dubois, Mexico City, president of the National Highway Commission of Mexico.

As a road building project fostered by the American Road Builders' Association for many years, the Pan American highway has tremendous possibilities for tourist and commercial expansion, as well as for betterment of international relations. It often has been referred to by orators and journalists as a "highway of understanding" and a "pathway to permanent peace in the Western world."

Working Days in a Year

The following table, giving the number of working days in a year for grading and paving in the several states, should be of general interest to contractors performing this kind of work. It is included in the 1929 convention proceedings of the American Road Builders' Association. The figures given represent the estimated working days, exclusive of Sundays, holidays and bad weather.

State	Grading	Paving
Alabama	240	240-300
Arizona	200-300	200-300
Arkansas	300	300
California	155-300	120-300
Colorado	No data	No data
Connecticut	200-240	125-155
Delaware	220	160
Florida	240	240 up
Georgia	300	300
Idaho	120-200	80-120
Illinois	180-240	120-135
Indiana	160-175	120-140
Iowa	175	125
Kansas	200	140
Kentucky	175	100
Louisiana	225	225
Maine	140	110
Maryland	180-240	140
Massachusetts	225	150
Michigan	180	130
Minnesota	150	100
Mississippi	240	160
Missouri	No data	No data
Montana	No data	100-120
Nebraska	250	225
Nevada	240-300	150-175
New Hampshire	140	100
New Jersey	No data	No data
New Mexico	No data	No data
New York	160	150
North Carolina	200	200
North Dakota	150	180
Ohio	No data	No data
Oklahoma	225-240	225-240
Oregon	No data	No data
Pennsylvania	190	120-140
Rhode Island	190-200	140-150
South Carolina	210-240	180-240
South Dakota	130-165	110-140
Tennessee	190	175
Texas	240-300	180-240
Utah	170-180	170-180
Vermont	155	115
Virginia	180-210	150-180
Washington	No data	No data
West Virginia	No data	160-200
Wisconsin	140-150	110
Wyoming	200	140-160

Construction and Maintenance of Gravel Roads

Practice in the Province of Nova Scotia, Canada

By R. W. McCOLOUGH
Chief Engineer, Department of Highways, Halifax, N. S.

THE increase in the number of motor vehicles in the Dominion of Canada during the past ten years has created a problem which all the provinces are striving with difficulty to solve. That problem is, with the means at our command, to provide satisfactory highways for an ever-increasing motor vehicle traffic. Statistics show that some of the states in the United States have already reached the saturation point of such traffic. That, however, is not the case in Canada, and we may expect a considerable annual increase for some years to come. Moreover, with the construction of trunk highways, our problem is made harder by reason of the fact that owners of motor vehicles in the more remote districts demand highways having riding qualities of a standard but little below that of the trunk roads.

Status of Canadian Roads.—Of our total road mileage in Canada approximately 90 per cent is unsurfaced, 9 per cent has been surfaced with gravel or crushed stone, and about 1 per cent has been paved. Considering our great mileage of highways, our comparatively small population, and therefore, limited means, and the fact that the greater percentage of our highway mileage has not, as yet, been surfaced at all, it is obvious that, with the exception of the more thickly populated sections of the Dominion, our improved highways for some years to come must consist of low cost roads, and this usually means gravel surfacing.

With sufficient funds it would be easy for us to build excellent paved roads. In this country, however, our problem is to bring relief to a large area that would have to wait many years for the construction of high cost roads, and in the meantime would be paying a high cost per mile for its motor vehicle transportation.

Unfortunately we in the older provinces seldom have the opportunity of locating and constructing a highway where none previously existed. In most cases we have to improve an old road, which has very often been improperly located, and, in some instances, has developed from a path. It is essential before finalizing the alignment, grades, width, etc., that we try and arrive at some idea of what traffic the road will carry in the future, and then construct the road to a standard that will serve the traffic for a reasonable period of years.

Sub-grade Widths and Crowns.—It is generally conceded that 30 ft. is the desirable sub-grade width for a highway which has to carry any volume of traffic, and it is certainly most unwise to construct a sub-grade less than 26 ft. in width. It is difficult and expensive to widen a highway after it has been surfaced, and this entails the lengthening of culverts and further interference with the property of the owners of land along the right-of-way. It is essential that all curves be well banked.

A crown of ½ in. to the foot is ample for gravel surfaced roads. If a greater crown than this is allowed the traffic will hold to the center of the road instead of travelling over the entire width. This is bad both from a safety and maintenance standpoint. A high crown will produce rutting, and the action of the motor vehicle wheels in trying to stay in the center of the road will tend to tear out and throw the gravel to one side. If desired, the sub-grade may be crowned. This refinement, however, is hardly necessary, as the small amount of crown required can be taken care of in the surfacing.

Drainage System.—The drainage system must be so constructed as to take away all water as quickly as possible and before the time element has a chance to damage or weaken the road.

When the magnitude of our highway construction program is considered and the vast amount of money spent on maintenance is taken into account, it may safely be stated that the greatest field for economy lies in the development of a sub-grade at the least possible expense, which will maintain a maximum stability at all seasons of the year. Therefore, provision must be made for the following:—

(1) Sufficient crown quickly to remove the water from the travelled way to the side ditches.

(2) Side ditches of sufficient capacity to carry the water to drainage structures and offtake ditches.

(3) Drainage structures of sufficient capacity.

(4) Offtake ditches that will function expeditiously.

(5) Side ditches sufficiently deep to keep the water table well below the sub-grade.

(6) Sub-drainage where required.

Usually the side ditches, if of sufficient depth, will keep the sub-grade dry. In certain soils, however, it will be found that when the frost is coming out in the spring the ditches may be practically dry, while the sub-grade will be wet and impassable. In such cases, it is usually necessary to construct a sub-drainage system. However, in constructing a sub-grade which is to carry a low cost gravel surface, it is not necessary to anticipate during construction every possible cause of failure, as would be necessary in constructions for a high cost paving. It is usually economical to take a "chance" on a few failures, whether due to drainage or due to placing a fill on a bog or other bad foundations.

Grading Methods.—I will not attempt here to discuss in detail the various methods and machinery which may be used on road construction, I will, however, say that the time of the day laborer, the pick and shovel, the wheelbarrow and the horse and cart has passed for all highway jobs of any magnitude. If the grading is in flat country where very little rock is to be encountered, it can be carried out at low cost only by the use of the blade grader and the elevating grader with heavy tractor power units and with motor trucks and motorized scrapers for making the fills. If the work is in hilly or rough country, the crawler shovel, air compressor, tractor and motor truck are required. Without modern machinery, quantities cannot be moved on highway construction at a low unit cost.

Before the road surfacing is placed on the sub-grade, it is essential that the sub-grade be carefully reshaped, preferably with a blade grader. All unevenness, bumps, depressions and ruts must be eliminated, and the roadbed made to conform absolutely to the cross-section required by the plane. It is not only costly but difficult to remedy a bad sub-grade with surfacing material, and obtain a smooth surface on the completed roadway, unless the sub-grade has been so completed. It will usually be found necessary to reshape the sub-grade immediately ahead of the surfacing owing to the roughening action of traffic.

There are three principal types of cross-section used for gravel surfacing —the feather edge, the trench and the spill-over, the spill-over being a combination of the trench and feather edge sections. It usually involves considerable extra expense to use the trench section or the spill-over section, and for that reason, the feather edge section is the most popular in Canada.

Placing Surfacing Material. — One method of placing surfacing material that will give satisfactory riding qualities to completed roadway, is to dump

the surfacing from the vehicles either on the sides or in the center of the sub-grade and spread with a blade grader. The old method of dumping the material on the sub-grade and spreading by hand invariably created a bumpy road. The action of the blade grader not only ensures an even distribution of the surfacing material, but tends to mix the various loads brought out from the pit, and it will usually be found that there is a variation in the material brought out. By mixing, the surface is made more uniform.

It is usually wise to begin the surfacing at the point nearest the source of supply, and to insist that the vehicles carrying the surfacing travel over the entire width, thus avoiding the rutting of the surfacing and producing a uniformly compacted surfacing over the entire width of the travelled way.

Gravel should not be bladed on the travelled way in such quantities as will inconvenience motorists by forcing them to drive through a considerable depth of loose material. The amount which can be drawn in at one time depends entirely upon the binding qualities of the surfacing material; usually about 2 in. in the first instance is sufficient. The use of road rollers adds considerably to the cost and generally the surfacing can be consolidated by the traffic without seriously inconveniencing the motorist.

Size of Gravel.—In order to reduce the cost of our surfacing we sometimes construct two courses. The bottom course, which is usually about 4 in. in thickness, is required to pass a 1½-in. ring; while the top course, which is 2 or 3 in. in thickness, is required to pass a 1-in. ring. We prefer, however, to surface our highways with material all of which will pass a 1-in. ring. Some engineers now advocate that all material for surfacing should pass a ¾-in. ring. I believe this will produce surfacing which will give better riding qualities. However, it must be remembered there is a considerable difference between the cost of producing material which will pass a 1-in. ring and that which will pass a ¾-in. ring.

Crushed Gravel.—In our first road construction in Nova Scotia we used gravel for surfacing which was practically pit run, and which contained, in some cases, stones up to 3 in. in size. From this we passed to the screening of the material so that nothing was placed on the roadway which would not pass a 1½-in. ring. Today we are crushing practically every yard of material which is being used on our highways. For this purpose, we are using specially designed modern portable crushing and screening plants where the material is available locally. We have in addition three non-portable crushing plants equipped with gyratory primary breakers and gyratory reduction crushers for the purpose of shipping material by rail to localities where no material is available locally.

When we screened by hand or used small screening plants fed by horses with drag scrapers we found that our cost for loading in the vehicles was usually in the vicinity of 80 ct. per cubic yard. In addition to this, the oversized rocks, which really contain the best road material, were wasted, and as in most localities, there is not an over abundant supply of surfacing material, it is necessary to conserve every pound.

While our larger portable crushing plants cost us in the vicinity of $19,000, we have been able to load material in the vehicles crushed so as to pass a 1-in. ring at a cost of less than 50 ct. per cubic yard, the actual cost of labor, fuel, etc., being less than 30 ct. to which we added 20 ct. per cubic yard to cover the cost of depreciation on machinery. These plants have a capacity of from 150 to 300 cu. yd. per day, depending on the amount of oversize in the pit, the figure of 150 cu. yd. per day being for a pit which contains practically 100 per cent oversize.

All our plants, both portable and permanent, are equipped with drag lines, the bucket of which hauls material to the conveyors.

Our permanent plants have cost us in the vicinity of $30,000 each, but they are delivering material to the railway cars at a cost of less than 50 ct. per cubic yard, making allowances for all charges including depreciation of machinery. As already stated, the permanent plants are equipped with gyratory crushers and the cost of production will depend very largely on the amount of oversize in the pit and the hardness of the stone to be crushed.

Clay Binders.—We find that many of our pits in Nova Scotia do not contain sufficient binder, and for this reason, it is necessary to add clay, in order to produce a proper binding of the surfacing. Where the material in the roadway which is being graded is suitable for this purpose, we usually leave a windrow on each side of the sub-grade. When about 3 in. of the surfacing has been placed this windrow of clay or hardpan is brought over the surfacing with a blade grader and, in most cases, we have been able to consolidate the gravel surfacing by this means. It, however, should be observed that an excess of clay binder is injurious to the surfacing in that it is liable to set too hard in dry weather and to become slippery in wet weather. We usually find that about 12 per cent is sufficient volume of clay to add to the surfacing, and clay is only added when the qualities of the gravel are such that it will not consolidate without the addition of binder.

Hauling Surfacing Material. — We formerly used to state that a haul up to two or three miles could be economically carried out with horses. I think, however, that it has been clearly demonstrated to all of us that the horse is not economic for any length of haul.

In Nova Scotia, while the department owns a considerable number of 2-ton trucks, we find that we do our cheapest hauling by using hired "Ford" and other light trucks. These are owned by farmers and others in the locality, and are hired by the department at a rate of $1.00 per hour including driver and all other charges. The trucks are only paid for the actual time which they work on the road. It may be said by some that it is not possible for truck owners to hire trucks at this rate. Nevertheless more are offered to us in Nova Scotia at this rate than we require. This is probably due to the fact that the owner required the truck for other purposes, and the money received for road work is usually clear gain. Very often the truck is driven by the owner's son, or his hired man.

Importance of Proper Maintenance.—Deterioration of a gravel road can be averted only by vigilant maintenance. The riding qualities of a gravel road more than that of any other type are affected by the class of maintenance to which it is subject. If perfect riding conditions are to be maintained systematic maintenance is essential and this means a patrol system. The length of the patrol depends upon a number of factors: density of traffic, quality of surfacing materials, climatic conditions, etc. The length will vary from three to six miles.

Proper equipment is the first essential of a satisfactory patrol. Maintenance work should be effected by machinery wherever possible, and the foreman or patrolman should be supplied with the necessary additional labor. The patrolman should not undertake heavy repairs; these should be left to a foreman with a special gang. In this way the regular foreman or patrolman is enabled to attend to his ordinary duties.

Spring Maintenance.—In the spring of the year in this country, the surface of a gravel road, due to the action of frost and traffic, is usually rutted and does not conform to the cross-section to which it was constructed. If the spring maintenance is undertaken immediately after the snow leaves the travelled way for two weeks, the surface reshaped without difficulty, which condition is usually not true at any other season of the year. A dollar spent at this season of the year will face of the roadway, being plastic, can accomplish more than three dollars can perform a month later. For these reasons in Nova Scotia our first step in the maintenance of our gravel roads is completely to rip up the surfacing down to the sub-grade. For this purpose, we use our 10-ton tractors and 12-ft. blade graders. This work usually requires from five to nine cuts of the blade grader. The first cuts are usually made along the center of the roadway, practically the entire surfacing being

turned out to the shoulders. The material is brought back by the side cuts, and the roadway made to conform to its proper cross-section. The patrolman, therefore, is handed his section in perfect condition in which to begin his year's work, and he is expected to maintain it in this condition throughout the season. The result of this, our first step in our maintenance, is to regrade the gravel so as to bring a considerable portion of fines back to the surface, and to eliminate all unevenness.

As some of the surfacing placed during our early construction contained many large stones, our first year's operation, as outlined above, entailed considerable work in throwing away the oversize, and in some cases, we found it necessary to use a scarifier.

Our experience in road surfacing in Nova Scotia has taught us at least one thing and that is that oversize material is absolutely useless in roadway surfacing, that the place to eliminate this is in the pit, and that the only safe and economic way of doing this is by the employment of modern crushing and screening plants.

There are three principal operations necessary to the keeping of an untreated road surface serviceable:

(1) Addition of new materials which are similar to those in the existing surface.

(2) Blading and digging.

(3) Patching.

In addition to the foregoing, it may sometimes be necessary to scarify the surfacing.

Addition of New Material.—Formerly we obtained our maintenance material by either hand screening or by using horses to drag scrape the pit run gravel to a trap and thence over a grizzly or to a rotary screen. This method is not only costly, but results in the loss of the hardest particles of stone. Today the greater percentage of our maintenance material is produced either by permanent crushing and screening plants or by portable crushing and screening plants, the former being for shipping maintenance material by rail to points where none is available locally and the latter for use where the material is available locally.

Undoubtedly the best time to apply maintenance material is in the fall and spring. This method, however, involves the stock piling of the material on the roadway, owing to bad hauling conditions at this time of year, and there is also some objection to this owing to the extra cost of rehandling the material. It is, however, advisable to have a certain amount of material stock-piled along the roadway.

Maintenance Gravel.—The kind of gravel used is an economic problem, the factors being durability and cost. It is understood, of course, that the material used must give satisfactory riding qualities. Extremely hard gravel does not make the best maintenance material. Ideal gravel for maintenance is one which is soft enough to break up sufficiently to supply fine material, but will not produce mud, and has sufficient hard material to leave a light coat of free gravel of pea size on the surface.

The amount of material which must be added yearly depends not only on the traffic carried and the climatic conditions, but also on the quality of the maintenance material. With a well constructed roadbed carrying 700 to 1,000 vehicles per day, it will be found that an average of 200 cu. yd. per mile must be replaced each year. As there should always be a small reserve of gravel on the shoulders of the roadway, sufficient width for that purpose must be provided at the time of construction.

Blading and Dragging.—The blading or dragging of a gravel road can be attempted by so many methods, and some sort of result accomplished by each, that it is difficult to determine which is the proper course to adopt. The amount of traffic, climatic conditions, drainage, kind of sub-soil, width of road, equipment, funds available and characteristics of gravel at hand for repair all have a bearing on the maintenance methods.

In Nova Scotia we are successfully maintaining gravel roads which have an average traffic of more than 2,000 cars per day during the summer months. When the traffic is this heavy, however, there is great complaint on account of the dust nuisance, and for this reason, it is necessary to apply a dust layer of one kind or another. I, however, believe that when the traffic exceeds 1,500 cars per day, it would be more economical to construct a higher type of paving, and in this connection, I might point out that where our traffic reaches 2,000 cars per day our maintenance cost is approximately $1,000 per mile per year.

Continuous Maintenance Essential.—Continuous maintenance is essential on a gravel road. The old practice which had the farmer working on the roads when there was nothing else to do is wrong—not only economically, but from the viewpoint of maintaining proper riding qualities. Maintenance forces must be organized so as to give continuous service, and so as to keep the roads in repair at all times.

It is most essential that the gravel road be kept smooth continuously, and the work of keeping the road smooth should start at the time of construction. Once a gravel road is allowed to become pot-holed or rutted it is beyond the stage where it can be cared for with the ordinary maintenance machinery, and it will be necessary to bring in heavy machinery and perhaps resort to scarifying.

The method used for dragging the road will depend on the various conditions encountered. It is essential, however, that, even the simple matter of dragging be given careful thought by some responsible official, and the methods used not left to the patrolman on the road. The ordinary layman does not realize the importance of trained personnel both in highway construction and maintenance. The idea that any laborer can do the work is wrong.

The roadway should be dragged as often as may be necessary, regardless of weather conditions, to keep it smooth, and to maintain a coat of free gravel. This frequency depends not only on the volume of traffic, but also on the characteristics of the sub-grade and the surfacing material. However, on an average, it is necessary to drag it after every 1,000 vehicles have passed. Operating road maintainers at a speed in excess of about three miles per hour is not only very detrimental to the machinery but causes the machine to leap over the bumps instead of cutting them off. It is, therefore, essential that maintainers be operated at a reasonable speed.

Grading Equipment.—The class of equipment which we should employ for the purpose of maintaining a road depends not only on the traffic that the road is carrying, but also on the width of the roadway, and the characteristics of surfacing material. On roadways carrying light traffic, the old fashioned drag or the horse-patrol grader weighing in the vicinity of 1,200 lb. will prove adequate. However, on the more heavily travelled roads we have found that it is practically impossible to maintain a smooth surface with the horse-patrol graders. We have, therefore, in Nova Scotia for the past several years been experimenting with motor-patrol graders. We have three types in use:

(1) The multi-blade drag pulled by a 3-ton Caterpillar tractor.

(2) The single blade maintainer powered with a 3-ton Caterpillar tractor.

(3) The single blade maintainer with rubber tire wheels.

Cost of Maintenance.—We have found that the cost of maintaining with motor patrols is a little below that of maintaining with horses. The motor maintainer will maintain from 25 to 30 miles of roadway under heavy traffic and keep this mileage in excellent condition. Our operating costs are about $10.00 per day for the machine, $5.00 per day for operator, $6.00 per day for gas and oil, totalling $21.00 per day. As the machine travels approximately 30 miles per day the cost per mile is approximately 70 ct. per mile travelled. The horse grader will cost $6.00 per day and will cover approximately 12 miles, or 50 ct. per mile travelled. But as the weight of the horse machine is only a fraction of the power grader, and as the blade is usually only about one-half the length, it can be assumed that the horse grader is not doing over one-half the work of the motor patrol.

Acknowledgment.—The foregoing is a paper presented at the 1929 meeting of the Canadian Good Roads Association.

Oiled Gravel Roads in Wyoming

Methods, Equipment, Costs and Benefits

By C. H. BOWMAN

District Engineer, Wyoming State Highway Department, Casper, Wyo.

THE writer a year ago read a paper on "Oiled Gravel Roads" at the conference at the University of Colorado. A particular project of 15.4 miles was discussed in detail and certain conclusions were drawn. It is some satisfaction to know that the general conclusions drawn at that time require little modification.

In Wyoming during the past working season, two state owned and state operated outfits constructed 67 miles of oiled gravel surface and reconditioned 14 miles. One outfit operating in the southern part of the state completed 36.5 miles of oiled surface and one in the central part of the state completed 30.6 miles of new work and reworked 14.3 miles of last year's work on which 0.46 gal. of oil per square yard was added.

Project Built in 1927 Reconditioned.—The 1927 work might be considered a partial failure inasmuch as the road has been reconditioned during the past season. However we do not so regard it because the results of careful observations on this project by those familiar with its construction were of great value in determining the materials and methods that would produce a better job than we had secured in 1927, after observation and study of California methods. It has been found in Wyoming that because of different climatic and soil conditions we must vary our methods somewhat from the California practice.

It might be interesting to consider the two conditions that required the reconditioning of 90 per cent of the 15.5-mile project of 1927. They were:

1. Insufficient oil used
2. Soft subgrade.

During the original work on this project those who were most familiar with this type of construction as practiced in California were convinced that the mix was too fat. For this reason when the job was about two-thirds completed, the metal was rescarified to a greater depth in order to secure additional material for a leaner mix. Early in the winter raveling began to develop and by spring this became more and more pronounced as the frost came out of the ground. When the frost came out of the ground after the melting snow and spring rains depressions began to appear at various places near the shoulders. Numerous test holes were dug where these depressions occurred and it was found that the gumbo shoulders were thoroughly saturated with water that had run off the oiled portion of the roadway. The oiled surface on this section was eighteen feet wide with three-foot shoulders of native gumbo. The crushed gravel had originally been placed six inches deep in a trench eighteen feet wide, with the gumbo shoulders outside the gravel. Frequently these places showed the additional fault of a thin mat. These shoulder breaks were very objectionable on account of the fact that with fast moving traffic of about five hundred vehicles per day, many of which were trucks, the traffic constantly took two lanes, and the outer wheel was increasing the depressions and forming an even more inviting place for the water to soak into the gumbo rather than drain over the shoulders.

Some shoulder patching was done but a mix which was too lean together with subgrade trouble resulted in a decision to rework practically the entire project with the exception of some short stretches near the end of the 1927 work, where a good subgrade and more oil had produced a surface which was in good shape in the spring of 1928.

This project was reworked in the following manner. Approximately ½ gal. of oil per square yard was added and an attempt was made to secure a 3-in. mat, guarding as much as possible against tapering at the outside edges. Much wet, cold weather occurred during this work, and after the job was completed a few shoulder breaks appeared again. These were repaired by hand. The saturated gumbo was usually from 6 in. to 12 in. in depth. It was removed and the material from the original oil surface was tamped into the bottom and covered with a fresh mix. The material was mixed with the oil in a concrete mixer. People who used the road could not see these breaks as they travelled over the excellent surface at 40 to 60 miles per hour, but to those who were responsible for the job, every incipient break stuck out like a sore thumb. One citizen called up the state highway engineer and asked why we were tearing up a perfectly good road.

Patches which were made became scarcely discernible after traffic had ironed them out. This stretch of road is in splendid condition throughout its entire length at the present time, but some trouble is anticipated after the melting snows and the spring rains. It is believed that if the oiled gravel surface were 20 ft. wide instead of 18 ft., the trouble of breaks on account of soft shoulders would be reduced greatly and possibly eliminated. We have arrived at exactly the same conclusion as Mr. Bail who states, "We have found 18 ft. too narrow and intend to make future treatments 20 ft." The speaker would like to see a full metaled section 20 ft. wide with feather edges at the shoulder line, rather than to have the earth shoulders which are now outside the gravel. It is also believed that more crown than the average 3 in. in 24 ft. would improve drainage and lessen the danger of shoulder breaks.

With gravel, sandy loam, or volcanic ash base shoulder breaks due to the sponge-like action of the gumbo shoulders would not so readily occur. The speaker's inspection of oil surface jobs in Idaho on volcanic ash subgrade showed no shoulder breaks due to saturated shoulders although traffic had ravelled the thin edges of the 18 ft. oiled section until at places one had to travel with one wheel off the oiled surface, in order to avoid a possible accident on account of a collision.

Asphaltic Oils Used.—For the project built in 1927 the oil was furnished by the Midwest Refining Co. at Casper under the following specifications:

"Oil asphalt shall be a natural asphaltic base crude and shall have a specific viscosity (Engler) at 122 degrees Fahrenheit of not less than 25 nor more than 45.

Water and Sediment—water and sediment combined shall not exceed more than 2.0 per cent.

Asphaltic Content.—The oil shall contain not less than 60 per cent nor more than 70 per cent of asphaltic residue, having a penetration of 80 at 77 degrees Fahrenheit.

Test Methods.—Test methods shall be as defined in U. S. Department of Agriculture Bulletin 1216 for all materials and tests involved."

Inasmuch as the project had to be reworked it has been suggested by some that the California oil was superior to the Rocky Mountain oils, although chemists have stated that they could not find any difference chemically. In order to ascertain if there was a difference, enough oil was shipped in from California to try a carload of the California oil on a section in each project, alongside of the two oils produced by the White Eagle and Midwest Refining Companies at their refineries in Casper. To date no difference can be observed in the condition of the different stretches regardless of whether California, White Eagle, or Midwest oil has

been used. Average oil content of the mixtures was approximately 4.75 per cent.

Aggregates. — Aggregates treated consisted of selected material; crushed gravel; crushed lime rock.

Our specifications for selected material are as follows:

"Selected Material Surfacing shall consist of gravel, rock, shale, or other approved materials together with sand, clay or other binding material, all taken from pits designated on the plans, all passing a screen with one-inch circular openings, and not more than twenty-five per cent passing a No. 10 sieve."

Our specifications for crushed gravel or rock are as follows:

"Gravel or crushed rock shall consist of hard durable rock or gravel of high resistance to abrasion, taken from quarries or pits designated on the plans. The material shall be well graded from maximum size to dust, all passing a screen with one-inch circular openings, and not more than 50 per cent passing a screen with one-quarter of an inch openings, and not more than 25 per cent passing a No. 10 sieve."

A closer specification will undoubtedly be adopted in future work where oiling is contemplated. More fines are required if a good job is to be secured. It is desirable to have 5 to 10 per cent of material pass the 200-mesh and 45 to 75 per cent pass the No. 10 mesh sieve.

One project of crushed lime rock 5.874 miles in length was oiled in the southern part of the state. This job is showing raveling at the present time and appears to be deficient in oil. It is believed that all the trouble is due to lack of oil and that lime rock can be oiled as profitably as the siliceous aggregates. Crushed lime rock is difficult to mix in that much turn-over is required to coat the aggregate with oil. Furthermore it sets up very quickly and if traffic is allowed on the surface when partially completed, it may have to be rescarified before it can be bladed.

Methods and Equipment.—Methods and equipment used in our 1928 work were very similar to those used by New Mexico. We do not consider that we had an ideal outfit in either the central or in the southern parts of the state. We used whatever could be obtained and robbed our regular maintenance work to some extent.

In the central district, with which I am most familiar, we used "30" Caterpillars with 10-ft. blades for mixing and spreading. A five-ton army tractor and Adams maintainer were used on some jobs for compacting while on other jobs a blade was used instead of the Adams No. 6 maintainer. A 10-ton army Holt was used to pull a No. 14 Adams grader for scarifying and shaping ahead. On the job in the southern part of the state, Adams No. 11 one-man tractor Caterpillar units were used for mixing.

The "30" Caterpillars with 10-ft. blades for mixing were very satisfactory and could be operated all the time in high while mixing, giving a satisfactory speed to secure the most rapid mix.

Construction Costs.—Included in this discussion is a table showing costs on the twelve oiled surface projects which have been completed in Wyoming. These projects are of various lengths and the material which has been treated is different in each case. Accurate cost records were kept and these costs may serve as a guide to those who contemplate doing this work for the first time.

Length of project, type of material and the various items entering into the cost are shown per square yard and per gallon of oil, as well as the total cost in cents per square yard and dollars per mile. These costs were compiled in one report in the office at Cheyenne from the cost statements prepared by the men responsible for the two outfits.

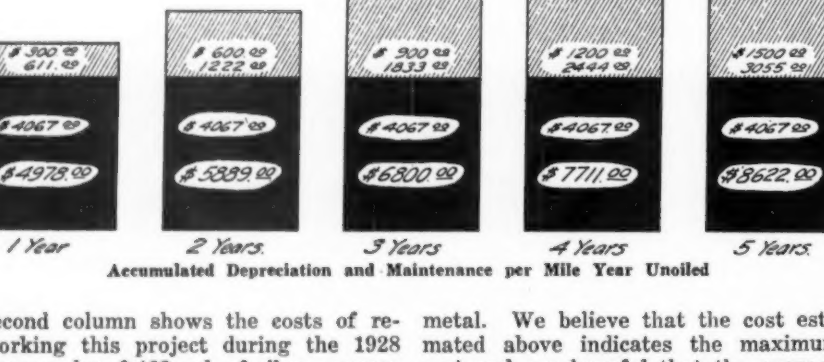
The first column shows costs on the original project built in 1927. The

Analysis of Cost of Oiling by Mix Methods on 12 Roads in Wyoming

Project Number	19C	19C	30	168 B	152	156 B	186 A	153	37 A	168 A	85	110	Average
Location	Casper-Salt Cr.	Casper-Salt Cr.	Casper-Salt Cr.	Casper-West	Laramie-North	Laramie-Bosler	Rawlins-Parco	Laramie-East	Torrington-Lingle	Casper-West	Casper-West	Casper-West	
Length of Project	15.49	14.313	3.475	11.398	8.47	9.84	5 874	3.20	9.19	3 468	10.00	2 349	
Material	Crushed Gravel	Crushed Gravel	Selected Material	Selected Material	Selected Material	Crushed Gravel	Lime Rock	Silty Sand	Crushed Gravel	Selected Material	Selected Material	Selected Material	
Width of Pavement	18 Ft.	18 Ft.	18 Ft.	22+ Ft.	18 Ft.	18 Ft.	20 Ft.	18 Ft.	18 Ft.	18 Ft.	18 Ft.	18 Ft.	18 Ft.
Thickness of Pavement	2 In.	1 In. Add.	3 In.	2½+ In.	3 In.	3 In.	2 In.	3 In.	3 In.	3 In.	3 In.	3 In.	3 In.
Total Oil Used Gals.	158840	69838	46079	193698	123168	163923	79698	54708	158275	63140	157696	37714	
Gals. Oil per Sq. Yd.	0.970	0.462	1.256	1.448	1.377	1.5775	1.160	1.618	1.630	1.724	1.493	1.521	
Gals. Oil per Mile	10254	4960	13260	16994	14542	16659	13567	17096	17223	18206	15770	16055	
Cost Per Gallon													
Oil at Plant	0.0450	0.0400	0.0400	0.0387	0.0395	0.0366	0.0258	0.0400	0.0375	0.0375	0.0400	0.0375	
Freight	0.0089	0.0013	0.0078	0.0067	0.0314	0.0309	0.0377	0.0289	0.0183	0.0087		0.0101	
Demurrage	a	a	a	a	0.0010			0.0042	0.0003				
Heating in Cars	0.0017	0.0012	0.0033	0.0012	0.0016	0.0023	0.0040	0.0019	0.0034	0.0026		0.0030	0.0020
Loading	0.0006	b	b	b	b	b	b	b	b	b	b	b	0.0006
Hauling	0.0099	0.0181	0.0058	0.0077	0.0040	0.0034	0.0046	0.0057	0.0046	0.0062	0.0056	0.0042	1 Mill Gal.Mi
Distributing	0.0060	0.0119	0.0057	0.0042	0.0049	0.0047	0.0041	0.0040	0.0032	0.0050	0.0044	0.0033	0.0044
Pro-rata Camp Exp.	0.0021	0.0010	0.0003	0.0005	0.0002	0.0001	0.0003	0.0001	0.0002	0.0003	0.0003	0.0003	
Pro-rata Supt. Exp.	0.0018	0.0033	0.0009	0.0015	0.0017	0.0012	0.0020	0.0015	0.0010	0.0012	0.0013	0.0016	0 0024
Pro-rata Moving Exp.	c	c	c	c	0.0009	0.0001	0.0005	0.0003	0.0019	c	c	c	
Pro-rata Misc. Labor	c	c	c	c	0.0012	0.0007	0.0021	0.0007	0.0010	c	c	c	
Total Cost per Gal.	0.0760	0.0768	0.0638	0.0605	0.0864	0.0800	0.0811	0.0873	0.0714	0.0615	0.0516	0.0600	
Cost Oil per Mile	779.30	335.65	845.99	1028.14	1256.42	1332 72	1100.28	1492.48	1229.72	11196 69	813.73	963.30	
Cost Processing, etc., Sq. Yd.													
Scarifying, Shaping Ahead	d	0.0062	0.0074	0.0062	0.0065	0.0066	0.0059	0.0113	0.0072	0.0095	0.0070	0.0075	0.0079
Mixing	0.0315	0.0206	0.0195	0.0184	0.0223	0.0257	0.0213	0.0200	0.0202	0.0246	0.0180	0.0179	0.0210
Compacting	d	0.0041	0.0042	0.0050	0.0037	0.0033	0.0047	0.0044	0.0070	0.0049	0.0022	0.0033	0.0041
Pro-rata Camp. Exp.	d	0.0014	0.0013	0 0015	0.0009	0.0004	0.0010	0 0004	0.0008	0.0011	0.0011	0.0013	
Pro-rata Supt Exp.	d	0.0046	0.0033	0.0050	0.0069	0.0054	0.0070	0.0073	0.0051	0.0048	0.0042	0.0053	
Pro-rata Moving Exp.	d	d	d	d	0.0037	0.0006	0 0017	0.0016	0.0094	d	d	d	0.0100
Pro-rata Misc. Labor	d	d	d	d	0.0047	0.0032	0.0074	0.0025	0.0047	d	d	d	
Total Cost per Sq. Yd.	0.0315	0.0369	0 0357	0.0361	0.0487	0.0452	0.0490	0.0475	0.0544	0.0449	0.0325	0.0353	0.0430
Cost per Ton	0.344	0.805	0.260	0.317	0.354	0.329	0.535	0.346	0 396	0.327	0.236	0.257	0.313
Total Cost Oil Processing													
Per Sq. Yd.	0.1032	0.0724	0 1157	0.1229	0.1666	0.1719	0.1436	0.1806	0 1714	0.1502	0.1149	0.1259	
Per Mile	1090.00	764.65	1224.04	1442.93	1767 27	1818.39	1680.07	2004.01	1809.98	1586.25	1150.78	1330.31	

a Cost included in Freight Expense. b Cost included in Hauling Expense. c Cost distributed among other Items.

d Cost included in Mixing Expense, Camp Supt., Moving and Miscellaneous Expense pro rated ¼ to Oil and ¾ to Processing.

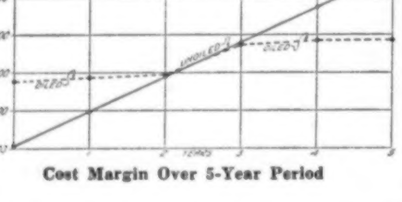


Accumulated Depreciation and Maintenance per Mile Year Unoiled

second column shows the costs of reworking this project during the 1928 season when 0.462 gal. of oil per square yard was added and a mat of approximately 3 in. was obtainable with a total of 1.43 gal. of oil per square yard.

Maintenance Costs.—We have been asked frequently by many different citizens, including engineers: "What is it going to cost to maintain this surface?" We can only reply: "At the present time we do not know."

After the second season's experience, however, we have, in Wyoming, some idea as to the maintenance cost, although these may be rather wide of the real costs. They are as follows:



Cost Margin Over 5-Year Period

First year—$100 per mile. Scarifying and patching.

Second year—$50 per mile. Scarifying.

Third year—$50 per mile. Scarifying and patching.

Third year—$750 per mile. Adding oil and reworking.

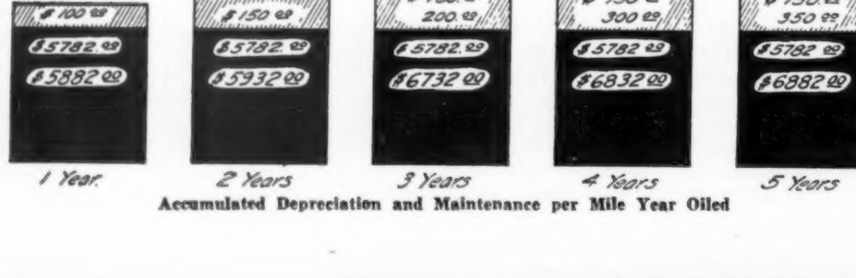
This would indicate an average cost of $330 per mile per year or approximately the average cost of maintaining an untreated gravel surface where motor traffic varies from 300 to 500 cars per day. In other words, the saving in maintenance of the oiled road would be the conservation of the road metal. We believe that the cost estimated above indicates the maximum cost and are hopeful that the average cost of maintenance may be less. Another advantage is the smooth dustless surface which is very attractive to the traveling public.

The illustrations give information which has been taken from department records. There is shown graphically the estimated cost per mile for a period of five years of an oiled road and also of an unoiled gravel surfaced road.

The curve for unoiled road is constructed as follows: Starting with the average cost of such gravel surfaces in our state of $4,067 per mile, there is added each year the two increments of $300 per year for maintenance and $611 per year for renewal of material. This makes the straight line curve shown and the investment in a mile of road will have reached $8,622 at the end of the 5-year period.

On the oiled road we start with the value of $5,782 which is the base price of one mile of gravel surface, plus $1,715 the average estimated cost per mile of oiled surface work. The first year we estimate $100 for maintenance; the second, $50; the third, $50; plus $750 for adding oil and remixing after which the same cycle would recur. At the end of the 5-year period the total cost of a mile of oiled road has reached the sum of $6,882 or the cost is $1,740 per mile less at the end of the five years on the oiled road, and in the meantime the people should have had a road that is commonly spoken of as "Better than pavement."

Acknowledgment.—The above is a paper presented at the 1929 Highway Conference at the University of Colorado.



Accumulated Depreciation and Maintenance per Mile Year Oiled

Hyde Approves Bill Detailing Engineers to Latin Republics

Approval of a bill that would authorize the President to detail United States engineers to assist Latin American countries in determining their respective highway programs is contained in a letter from Secretary of Agriculture Hyde, given out by Senator Tasker L. Oddie of Nevada. The letter carries an endorsement by the Acting Director of the Budget, reporting that in so far as the financial program of the President is concerned, there is no objection to the proposed report.

The bill was introduced at the special session of Congress by Senator Oddie, recently named by the President as one of the United States delegates to the Second Congress of Highways at Rio de Janeiro, Brazil. Secretary Hyde's letter was referred to Senator Oddie by Senator Lawrence C. Phipps, chairman of the Committee on Post Offices and Post Roads, of which Senator Oddie, who has sponsored many important highway bills, is one of the ranking members.

"It is believed," writes Secretary Hyde, "that timely and valuable assistance may be rendered these countries by the United States, when such assistance is desired, in furnishing advice and assistance to their own engineers and highway officials as to the practical operations involved in properly designing highways and bridges and in the handling of materials and equipments for their construction in an economical manner.

"All of the republics to which the bill would apply have engineers that are well trained in the technique of road building, but few of them have had an opportunity to acquire practical experience in carrying on a highway construction and maintenance program of magnitude.

"It is believed that such information could best be made available by the assignment of engineers in accordance with the provisions of the bill, and that the detail of experienced engineers in the manner proposed would serve to stimulate and cement a more friendly relationship and better understanding with our sister American republics."

This is the second favorable report of the Department of Agriculture, a bill similar to the present one, introduced in the Seventieth Congress, having the endorsement of Secretary Jardine.

The bill, if approved by the Senate and the House, authorizes the President upon application from the Latin American republics to detail engineers of the Bureau of Public Roads to assist in highway matters.

Method of Inspection of Mineral Aggregates

An Efficient and Practical Procedure Outlined

By A. S. REA
Chief Engineer, Bureau of Tests, Ohio Department of Highways, Columbus, O.

ASSUMING that provision has been made in the matter of organization by the user, whether it be a unit of national, state, county, or municipal government, or private organization to handle inspection of materials, certain fundamental rules can be laid down in the methods to be followed. With the varying conditions existing both as to locality and types of construction it is recognized that it is impracticable to formulate specific directions which would be applicable generally. For this reason no attempt will be made to enumerate in detail, instructions to be followed in the inspection and sampling of materials. The subject will be discussed for the most part by outlining in more or less general terms the methods and policies which have been used successfully by engineering organizations, and references will be made to standard methods or procedures that have been adopted.

The subject will be considered under the following sub-titles:

1. Preliminary Investigations;
2. Inspection During Construction;
3. Methods of Sampling; and
4. Field Tests.

Preliminary Investigations

Preliminary investigations of aggregates may be said to cover any examination or inspection of the source of supply prior to construction. In practice this may consist of either geological or material surveys, or reconnoissance or special preliminary examinations.

Material Surveys.—A number of the states as well as other political subdivisions of government have had very complete surveys made of their local resources. This has been especially true with reference to deposits of mineral aggregates. In some cases the survey has been conducted under the supervision of the state geologist, while in others it has been under the direction of the highway department. The information collected in a survey of this sort may be of inestimable value in planning and carrying out a construction program. A materials survey, involving the sampling and testing of the materials, is considered of such value that it is essential that the investigation should be in charge of someone who not only knows the geology of the state, but is also familiar with the character and use of construction materials.

Some of the important things to observe in a survey of this kind include the following: a detailed description of the deposit or quarry including the exact location; name of owner; the geological formation where applicable; the amount and character of over-burden or stripping; approximate quantity available; whether material from the same source has been previously used, where and for what purpose, and with what results. Notation should also be made of the shipping facilities, the plant equipment, if it is a commercial plant, and the approximate capacity of the plant. A detailed record of the extent and location of the material represented by each sample should be made. For this purpose a sketch, both in plan and elevation, showing the thickness and location of the different layers is recommended.

Special Preliminary Surveys. — In those states where no general materials survey has been made and even in those where such a survey has been conducted at a much earlier date, where possibly conditions have materially changed since the original survey, it is often desirable to make a reconnoissance or special materials survey. The plan usually followed when a construction project is proposed is to have an examination or survey made to determine what local materials are available and also their suitability for the particular type of construction contemplated. In some states, where conditions are such that it is considered impracticable to ship in material for particular projects, the specific requirements for the mineral aggregates are based on the test results of the best material available locally. A careful study should be made by the engineer of all surface indications and exposures and a sketch or map should be made of the project and adjacent area, from which it may be determined whether it is more economical to haul from the local deposit than to ship material from a commercial plant by rail. The procedure to be followed and the data which should be collected are essentially the same as that noted under "Material Surveys," except that perhaps less detailed information will usually be required.

Inspection During Construction

Assuming that the contract has been awarded and that the contractor has advised the materials engineer as to the source from which he proposes to obtain his mineral aggregates, the method of handling the routine inspection may be either by inspection at the source of supply or by inspection at destination.

An inquiry as to the methods followed by various states, counties, cities and organizations in this respect will reveal a marked difference in policy in the matter of inspection. Some states, for example, strongly favor the inspection of all aggregates at their source. In others the tendency is for inspection at destination, while in most states a combination of the two methods in varying ratios is the policy. Conditions, of course, determine more or less the practicability of the best method to follow. The chief advantage in the inspection at the source of supply of any material is in avoiding delay awaiting the results of laboratory tests. It also practically eliminates the possibility of rejection on the job with the resulting expense and delays involving re-shipments, demurrage, etc. The chief objection to this method of those favoring inspection at destination is based on the high inspection charges where the shipments are light, together with the fact that where conditions are favorable the plant inspection as applied to aggregates is considered unnecessary. It is held that where the quality of the aggregate is not in question and the plant operation is efficient, so that the grading or sizing is properly controlled, it is a needless expense to provide for plant inspection under such conditions. Where the quality and the grading as evidenced by the character of the product received is not satisfactory, plant inspection may be desirable and economical. In this connection it might be said that the more general adoption of field tests, as applied to aggregates, has resulted in the elimination of many delays in awaiting the results of tests on samples sent to a central laboratory.

Inspection at Source of Supply.—It is not the intention to enumerate the duties of a plant inspector nor to go into detail regarding the inspection methods to be followed for each type or class of fine and coarse aggregate, but rather to outline the general practice normally followed at plants producing aggregates for construction work and to call attention to some of the precautions to be observed.

The materials inspector is stationed at the plant for one purpose—to see that material being shipped complies with the requirements of the specifications and is satisfactory in every way. It is his duty to see that material being loaded is of approved quality and of satisfactory grading and uniformity, and in some cases to keep a record of the car weights. Inspectors located at plants furnishing fine and coarse aggre-

gates should make a careful study of plant conditions and operations, with a view to being able to make suggestions on improving the quality or uniformity of the product. In taking samples of aggregate, whether they are for his own field tests or are to be sent to the testing laboratory, he should keep in mind at all times that the one fundamental requisite is that the sample must be representative of the material being sampled. It is often a very difficult matter for the inspector or engineer on the job to secure a strictly representative sample for a car or stockpile, particularly of coarse aggregate. The inspector at the plant has a much better opportunity to obtain proper samples while the material is being loaded into cars or bins.

One of the very important things for an inspector to observe at a plant producing gravel, crushed stone or slag is the size and uniformity of grading. Some of the factors affecting the size of coarse aggregate at the plant are: size and shape of screen openings; length of screen sections; the angle of screen with horizontal; the speed of screen rotation; and the rate at which the screen is fed. A general inspection and record of these conditions should be made by the inspector.

Inspectors at plants producing aggregates should see that coal, cinders, and other foreign materials are removed from cars or barges before the aggregate is loaded for shipment. When the calking of car bottoms is necessary, the inspector should see that it is done in such a manner and with such material that the aggregates will not become contaminated with foreign material during the unloading operation. The use of boards, roofing paper or burlap has been found to be the most satisfactory for this purpose and their use should be encouraged by the inspector.

One of the important duties of the plant inspector is to see that accurate records are kept of all shipments and test results. He should also see that all samples sent to the laboratory are properly marked and identified.

Inspection at Destination.—Considering the construction and building program as a whole it is probably a conservative guess that over 90 per cent of the inspection on aggregates is at destination. While a few engineering organizations provide for plant inspection for practically all of their construction work, most of the states, counties, cities and private organizations provide only for the inspection and testing of the aggregates after delivery. The ratio of plant inspection to inspection at destination as applied to other construction materials, particularly manufactured materials such as portland cement and steel, would be much higher than with aggregates. This is due to the fact that the inspection of such materials as sand, gravel, stone and slag lends itself better to visual inspection and also perhaps to the fact that field tests are more adaptable to aggregates than to other classes of materials.

It has been found desirable by some organizations to handle the inspection of all materials at destination by specially trained materials inspectors. In most instances, however, the inspection of materials is supposed to be taken care of by the same engineer or inspector in charge of the construction work. Unfortunately the inspection of the materials has been in many cases sadly neglected. Too much dependence has been put upon the ability to judge the quality by visual examination. Conditions, however, are improving each year and more attention is given to the inspection and testing of materials.

The inspector or engineer responsible for the inspection of materials at destination should examine all shipments of fine and coarse aggregate upon arrival to determine so far as possible from an examination of the top of the car, if the material complies with the general requirements of the specifications relative to uniformity, cleanliness and freedom from foreign or objectionable material. Whereas the inspector at the plant has the opportunity to thoroughly inspect and sample the car as it is being loaded and is thus in a position to judge the quality of the entire shipment, the inspector on the job has much more of a problem in the inspection and sampling of the car prior to unloading.

Providing the quality and grading of the material are satisfactory so far as is possible to determine from a visual examination of the car, the next step is to take samples for field or laboratory tests. When samples are to be taken prior to the unloading of the car, special efforts should be made to secure as nearly representative samples as possible. Samples should be taken at a number of points including the middle and both ends of the car by digging holes at least 2 or 3 ft. deep and starting at the bottom of each hole, drag the point of the shovel up the side. The samples thus taken from each hole should be mixed and the composite sample quartered down to the desired size.

While ordinarily samples of each shipment are taken for either field test or laboratory test, it may be that at times the aggregate will be of such a character that the car may and should be rejected outright on the basis of visual examination alone; for example, a car of sand may be excessively dirty or badly contaminated with foreign material. Coarse aggregate for concrete, such as gravel, may be badly coated or contain clay lumps. Crushed aggregate, such as stone or slag, may obviously be of improper grading or may be exceedingly non-uniform, containing perhaps pockets of fine material or dust in the center and excess coarse material at the ends. In cases of doubt the material should be subjected to the field tests on the job or samples sent to the laboratory, but there are many instances in which the quality or grading is obviously so far at variance from the specifications that the inspector may be fully justified in rejecting the material without test.

Methods of Sampling.—The methods of sampling are considered separately from the inspection, for the reason that the sampling of materials is required under both material surveys and preliminary surveys as well as under routine inspection, whether at the plant or at destination. It is not considered necessary to go into detail as to just how the samples shall be taken or the quantity of sample required for each class of fine and coarse aggregate, for the reason that the methods of sampling aggregates are covered in one of the standard methods of the Society.[1] This method has been approved as "American Tentative Standard" by the American Standards Association and also with only slight modifications as a "Tentative Standard" of the American Association of State Highway Officials.

It is believed that experience has demonstrated that the methods of sampling prescribed in this standard have proved very satisfactory and practical, and that any engineering organization formulating instructions to inspectors would do well to refer to this standard as the basis for its sampling requirements.

Field Tests.—A discussion of methods of inspection would not be complete without reference to some of the more important "field tests" which are now in more or less general use in connection with the inspection of aggregates.

Field tests may be made at the source of supply or at destination. The most important of the tests in the field on fine and coarse aggregate are are following:

1. Screen Tests;
2. Silt Test;
3. Colorimetric Test for Sand; and
4. Weight per Cubic Foot.

Screen Tests—The field test in most general use is the grading or screen test of the aggregates. In many instances, particularly with crushed rock, the material has been subjected to complete laboratory tests for quality, so that it is only a matter of determining whether the aggregate is of satisfactory grading and uniformity. For this purpose the inspectors are furnished with screens and sieves, and either scales for determining the proportion of the various sizes by weight, or suitable cylinders or containers for volumetric determinations. The grading of an aggregate can be determined in the field practically as accurately as

[1] Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods (D 75-22), 1927 Book of A.S.T.M. Standards, p. 473.

in the laboratory, therefore, except in very extreme cases, it should not be necessary to hold up construction work pending the results of laboratory tests when only the size is in question.

Silt Test—The percentage of silt or clay in a sample of sand may likewise be determined in the field by a proper washing or elutriation test. The most accurate and satisfactory method is by the weight method, in which the silt is washed out in a specified manner and the loss in weight determined as described in the Society's Standard Method of Decantation Test for Sand and Other Fine Aggregates (D 136-28).[2] This method requires a source of heat for drying out the sample prior to and subsequent to the washing. A more rapid and simpler method sometimes employed as a field test consists in shaking a sample of sand with water, in a glass jar or cylinder, after which it is allowed to stand for a stated length of time and the percentage of clay or silt settling out on top of the sand estimated. The value obtained by this method is usually from two to four times that obtained by the weight method, depending largely upon the time allowed to settle; hence this method is only considered as a guide and may in cases of doubt necessitate a check determination by the laboratory.

Colorimetric Test—The colorimetric test for organic impurities in sand is one of the field tests which is now being used quite extensively. The test consists, briefly, in adding a 3-per-cent solution of sodium hydroxide to a given volume of sand in a graduated bottle and noting the color of the solution after 24 hours. If the liquid is colorless or has a slight yellow color the sand may be considered satisfactory in so far as organic impurities are concerned. The method is described in the Society's Standard Method of Test for Organic Impurities in Sands for Concrete (C 40-27).[3] The field method is the same as the laboratory method described in the standards, except that a color chart is used for comparison instead of employing colored solutions prescribed for the laboratory method.

Weight per Cubic Foot—One of the usual requirements in specifications for certain classes of coarse aggregate such as blast-furnace slag is a weight per cubic foot requirement. On inspections covering this type of aggregate, therefore, it may be required that this determination be made in the field. A determination of the unit weight of other coarse aggregates is also sometimes necessary in connection with weight proportion of aggregates for concrete and also in connection with designed mixes, where proportions are based on compacted weight of aggregates. A description of the method appears in the Society's Standard Method of Test for Unit Weight of Aggregate for Concrete (C 29-27).[4]

Those cited are the more important and generally used field tests in connection with the inspection of aggregates. Other special field tests employed where conditions require include such tests as a determination of the percentage of shale in gravel; the percentage of coke or coal; the percentage of clay lumps; the percentage of soft fragments; and the percentage of thin or elongated pieces. In some cases also where a crushed gravel is specified, it may require a field determination of the percentage of angular pieces in the aggregate.

Summary—It has been estimated, it is believed conservatively, that of the billions of dollars expended in this country annually for construction work, not less than 50 per cent is represented by the cost of materials incorporated in the work. Mineral aggregates play a most important part in this construction program, exceeding, from the standpoint of volume any other class of material used in construction work. Our highways and streets to the extent of over 90 per cent are composed of mineral aggregates. Concrete construction of all kinds will average approximately 85 per cent by volume of mineral aggregates.

It goes without saying that the protection of the enormous investment represented by this construction program makes mandatory the assurance that proper selection of materials be made. This can only be done by adequate inspection and test methods. This paper has attempted to outline an efficient and practical procedure to follow in the inspection of mineral aggregates, both at their source and at destination.

Acknowledgment—The foregoing paper presented in a "Symposium on Mineral Aggregates" at the 32nd annual meeting of the American Society for Testing Materials, held June 24 to 28, at Atlantic City, N. J.

[2] 1928 Supplement to Book of A.S.T.M. Standards, p. 161.
[3] 1927 Book of A.S.T.M. Standards, Part II, p. 123.
[4] *Ibid*, p. 120.

The U. S. Motorways Commission

The joint resolution now before Congress to create a United States Motorways Commission is hailed as an effective ally by the American Road Builders' Association in its fight for betterment of traffic conditions throughout the nation.

The commission would first consider the question of a national system of express motorways. These would take care of high speed, through traffic. Proponents of the express highways would have lanes for fast traffic in the center, slower traffic on the outside, and have traffic on all intersecting roads separated into different levels.

Senator Lawrence C. Phipps of Colorado, chairman of the senate roads committee, has asked Congress to authorize a non-salaried commission composed of two senators, two representatives, an official of each of the six government departments of labor, agriculture, post office, commerce, war and treasury and a civilian who is experienced in industrial, military, aviation and traffic problems. This group would study the many suggestions which have been made to relieve traffic congestion and then furnish a comprehensive report with recommendations to Congress and the President.

Representative John M. Robison of Kentucky sponsored the resolution in the lower house of Congress. Both he and Senator Phipps have long been champions of federal air roads.

"Such research," Senator Phipps declares, "might save years of haphazard investigation as well as hundreds of millions of dollars to the nation's taxpayers." It is believed that the study should be nationwide in scope, although initial projects would be put into operation where traffic conditions most demand. The senator believes the proposed commission would find great need of "feeder highways" to augment the federal system. He urges that these be built as rapidly as possible.

According to Charles M. Upham, secretary-director of the American Road Builders' Association much good can be accomplished by a motorways commission, and he has offered the research facilities of the Road Builders' to aid in the investigation.

"Highway planning of today must be with traffic requirements of the future in mind," Upham declares. "We will need broader and safer highways as motor vehicle registration advances toward the fifty million mark in the United States. Our state systems of gas taxation and registration fees make increased road building activity possible. Every cent of such funds collected must be returned to the highways in fairness to the motorist. Additional finances must be obtained by issuance of highway bonds in many cities and counties.

"Not only must we consider the expensive express motorways and the low cost rural roads, but the secondary routes must be given due attention, and all road building co-ordinated into one great national plan."

Concrete Toll Road Authorized in Parana, Brazil.—A law published May 25, 1929, authorizes the executive authority of the State of Parana to grant a concession for a concrete toll road of the Belgian type to join the Jaguariahyva, a junction point on the Sao Paulo-Rio Grande Railway, to the part of Paranagua. The construction of this road is a step toward the opening of the northern and northeastern section of the State, which is the best coffee land still awaiting development in Brazil. The distance between Jaguariahyva and Paranagua in a straight line is about 162 miles.

Durax Pavements for Steep Grades in Tokio

Methods of Construction in Japanese City

By YASUHEI EMORI

Paving Engineer, Department of Public Works, the City of Tokio, Japan

THE larger part of Tokio which is located confronting the Tokio Bay, occupies the plain area, but its back area, usually called "Uptown," is located in the hilly district. Accordingly, there are many steep grade streets in that district, their total length amounting to nearly 100,000 ft.

The traffic on the streets in Tokio is being motorized very rapidly, but at the present time the horse drawn vehicles can not be neglected, in selecting the pavements on the streets. The types of pavement for steep grades especially have been considerable of a problem for a long time, and various paving methods have been tried.

Durax Most Widely Used.—Of all of them, the durax pavement, or the klein plaster of cement mortar joint, known in Tokio as "Sho-hoseki," is most widely used on the steep grade streets and has been a decided success. Its durability, the roughness of its surface, and also the moderate cost of its construction are principal reasons for adopting it as a standard method of paving on grade streets steeper than 4 per cent.

The following is a table of durax pavements laid recently on steep grade streets in the city, and they are all giving satisfactory footholds to all kinds of vehicles.

Streets	Length (ft.)	Grade (%)	Area (sq. yd.)
Iigura-Dori	300	6.6—6.2	1,328
Toyokawainari-Dori	666	6.1—4.0	1,628
Kōjimachi-Rokuchome	936	8.3—5.0	2,672
Kioi-zaka	228	6.6	1,316
Yakimochi-zaka	1,212	6.6—4.7	4,500
Azabu-Kinoshita-zaka	300	4.7	1,176
Kita-Tomizaka	678	7.4—5.2	2,860
Tomizaka	780	7.4—5.0	2,252
Wakamatsu-chō	168	4.1	744
Yarai-dōri	630	6.3—4.0	776
Yushima-Kiridōshi	900	5.1—3.8	2,964
Hakusan-dōri	450	7.1—4.5	1,308
Miyake-zaka	390	5.5—5.0	1,040
Honmura-chō	582	6.6—5.2	1,016
Isarago-zaka	480	7.6—5.2	756
Takanawa-kitamachi	1,080	6.6—4.0	4,723
Dōzaka-dōri	402	7.1—4.0	1,268
Takebashi-dōri	162	5.0	840
Shin-mitsuke	630	6.6—5.8	936
Dango-zaka	438	9.0—5.8	1,176
Ichigaya-mitsuke	264	4.7—4.1	880
Total			36,146

(Authority—the City of Tokio).

Streets	Length (ft.)	Grade (%)	Area (sq. yd.)
Shibuya-Daikanyama	372	5.0	1.404
Shibuya-Machida	762	5.5	2,580
Kahi-meguro	774	5.0	3,128
Okubo	204	5.0	556
Goten-yama	804	6.2	5,372
Total			13,040

(Authority——the Prefecture of Tokio).

Grand Total			49,186

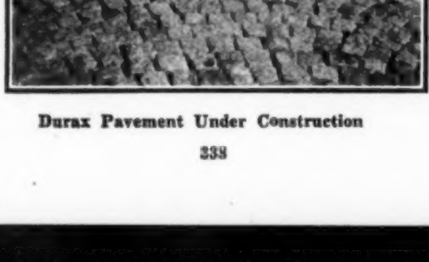
Durax Pavement at Dangozaka

Construction Features.—The foundations for the durax pavements are all of portland cement concrete of 1:3:6 proportion, laid on the prepared subgrade, to the thickness of 6 in. After the portland cement concrete is laid and cured for a certain period, granite durax blocks of about 3½ in. cubical size are laid with 1:3 cement mortar cushion underneath.

Blocks are laid in the form of circular arc as shown in the illustration, the reason of this being to get close joints as possible with the irregular size blocks, also to give an artistic appearance to the pavement. That this method eliminates those joints parallel to the traffic direction, may be considered to be another reason.

Design Features.—The chord length, l, can be designed by dividing the roadway width into a round number, the range of its value being between 40 and 60 in. The rise of the arc will be about 12 in. which can be reduced by a calculation from the given chord length, as the central being defined to be 90 degrees. The direction of the arc is usually set against the slope, in order to give an arch action to the pavement.

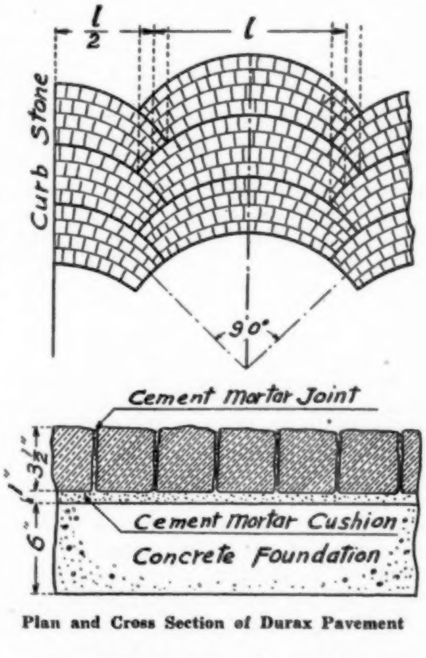
After each block is perfectly tamped in the cushion course, the cement mortar grout of 1:2 proportion is squeezed into the joints, making the pavement completely monolithic. Transverse or longitudinal cracks due to its monolithic construction sometimes appear, but as they do not occur often, not much trouble has been experienced up to the present time.



Durax Pavement Under Construction

The Durax Blocks.—Durax blocks are mostly of granite of fine grain from Ibaragi Prefecture and they have generally physical properties as follows: Specific gravity of more than 2.5, French coefficient of more than 15, and absorbing power of less than 1.6 lbs. per cubic foot.

At the quarry, blocks are cut from these materials into cubical form of 3



Plan and Cross Section of Durax Pavement

to 4 in. by hand or by the cutting machine. The durax blocks cost about 1.5 cents per block and as 94 blocks are required per square yard of pavement, the total amounts to $1.40 per square yard. The total cost of construction of the durax pavement, as related above, is not so expensive, a recent example being $4 per square yard including subgrading and 6 in. concrete foundation.

As this pavement is strong enough to stand up under very heavy traffic, as well as the ordinary large stone block pavement, there is a tendency to use it widely on the heavy traffic streets, besides those of steep grade.

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Does It Pay to Keep Country Roads Clear of Snow?

When snow lies on the roads all winter it packs during the cold weather and forms an ice cake over the roadway. Slight thaws help to form this ice cake. As spring approaches the ice melts, the water flows over the road surface, the cars cut deep ruts and a quagmire is the result. This condition is very well known to all highway officials, most farmers and many motorists.

The question has been asked, "To what extent is it justifiable to go in snow removal work?" Another question of importance and one which should require the attention of all county and state highway engineers as well as township officials is, "Is it economical to clean the ditches and culverts in the fall, prepare a good roadway and keep snow entirely free from the road surface all winter?"

In determining whether such a program is economical or not it is naturally assumed that a condition for comparison exists and that data are available. The comparable conditions would be the cost of maintenance in the spring as the frost is coming out of the ground when snow is removed and ditches are cleaned in the fall as against cost of maintenance in the spring as the frost is coming out of the ground when snow is not removed and ditches are not cleaned.

From past personal experience the writer is convinced that fall cleanup of ditches and culverts and keeping snow entirely clear from the roadway is an economical investment as well as a justifiable expenditure. Too often has the writer seen results of lack of snow removal. Too often has he seen cars mired down to the hub on main traveled earth and gravel roads simply because melting snow flowed down the ruts and trapped the water.

As the frost comes out of the ground it does so in a retarded manner. On roads where the snow was kept clear from the roadway, it was a little dusty all winter and spring. The moisture from frost coming out evaporates as rapidly as the frost rises. The roadway may be a bit spongy but it is dry and in condition for travel.

To help solve this question two roads could be placed on the experimental list. Traffic should be about equal on both roads and both should run in the same direction. On one of these roads the ditches should be cleaned out, culverts cleaned out, and roadway graded to proper cross-section in the fall. Then snow removal should be kept up all winter and all snow pushed over the shoulder of the roadway. On the other road none of these things should be done. Maintenance costs on both roads should be kept. This includes the grading as well as dragging.

The experiment should run until both roads are in the same condition and fit for travel. Expense and discomfort to travelers certainly should enter the picture. *Roads and Streets* will look forward to obtaining the results and data from such an experiment. How much can be saved in maintenance expenses in the spring due to fall clean up of ditches and culverts and complete snow removal?

The Amazing Electron

Take one-quarter of ten raised to the fortieth power, multiply it by the gravitative force of an electron and the product is its electric force. Electric force is so great compared with gravitative force as to appear an infinite beside an infinitesimal. This is one of the amazing revelations of modern science.

The electron is not only the smallest known unit of matter, but it is the unit charge of negative electricity. An electric current consists of electrons in motion; so Benjamin Franklin was right when he regarded electricity as a fluid. It matters not whether an electron flows through a conductor or whether it is stationary relative to an object that is itself moving (e. g. a rotating metal disk statically charged); an electric current exists in either case, for all that is essential is that the electron be in motion relative to the magnetic needle that registers its effect.

Every electric current, and that means every electron in motion, has a magnetic field, and produces magnetic effects. Curiously enough two quiescent electrons tend to repel one another, yet if they are both moving in the same direction they attract one another. Electric currents moving in the same direction attract one another. On the other hand electric currents moving in opposite directions repel one another. It follows that if a conducting wire is wound spirally and an electric current is sent through it, the coil becomes a magnet. The north pole of such a solenoid is the end about which the electrons are flowing anticlockwise when viewed along the axis of the solenoid by an eye nearer that end than the other end. Let the eye move to the other end, and the same current of electrons will be seen to be flowing clockwise around the spiral wire, and that end is the south pole. Hence a globe like our earth that is spinning on its axis and carrying electrons around with it is a magnet; so too is the air on that globe, for it contains free electrons; so too is every whirlwind, for the same reason.

It is a good working hypothesis to assume that every electron is spinning on its axis like a rifle-bullet, and that it is emitting particles of its own substance—call them etherites—and that the vortex of escaping etherites is the cause of the electric and magnetic fields. At any rate it is noteworthy that when the north pole of a solenoid is introduced into an atmosphere of free electrons they begin to rotate about the axis of the mag-

net in the same direction that the electrons are flowing, namely anticlockwise; and that when the south pole is introduced, they rotate clockwise. It is precisely as if a vortex of etherites emitted by the electrons in the solenoid current were propelling the free electrons.

The man most entitled to be called the discoverer of the electron is Sir J. J. Thomson. He was the first to determine its mass, and to give it a name. He christened it a "corpuscle," but the term "electron" has displaced that baptismal name. Thomson's discovery was made in 1897. Until quite recently it was customary to speak of negative and of positive electrons; but the name electron has come to be applied almost exclusively to the negative electron.

When an electron escapes from an atom, the atom is positively charged; but no one has ever isolated a positive electron. This suggests the thought that the positive charge may be due merely to a clockwise axial rotation of one of the electrons in the nucleus of the atom, the negative electron having an anticlockwise axial rotation. The nucleus of an atom of hydrogen has a mass about 1,860 times that of an electron. It may actually consist of 1,860 electrons, arranged in "shells" and rotating about the center of the nucleus.

Around the nucleus of each atom there are electrons revolving in elliptical orbits. These orbital electrons do not manifest the properties of a free electron, and are said to be neutralized by the positive charge of the nucleus. But under the influence of heat, or of low pressure, or of ultraviolet light, an orbital electron may escape; and it then is the unit negative charge, while the atom from which it has escaped becomes a unit positive charge.

A free electron is indeed a marvelous thing. Its energy is almost beyond comprehension. The editor believes that to the motions of free electrons in the earth and its atmosphere may be traced every important change of air movement on this globe.

The Declining But Great Risk of Air Travel

In our issue of August, 1929, we gave statistics of aeroplane fatalities compared with automobile and train fatalities, which showed that it is 146 times as dangerous to ride in an airplane as in an automobile and 5,120 times as dangerous as in a train, based on passenger-mileage.

Great as the danger of air travel still is, it is encouraging to know that the risk is about one-third what it was six years ago, if our navy and army statistics are indicative of the general improvement in air transportation.

During the fiscal year ending June 30, 1922, the navy planes flew 2,500,000 miles with 14 killed or 1 death per 164,000 plane-miles. During the fiscal year 1928, 13,500,000 miles were flown with 28 deaths, or 1 death per 471,000 plane-miles. During the fiscal year 1929, the deaths were 1 per 392,000 plane-miles, which was worse than in 1928.

The army flying has tripled in 7 years, with a corresponding decline in fatalities. Last year there was 1 death per 352,000 plane-miles. At this rate an army pilot flying 20,000 miles a year would have a life expectancy of about 18 years, which compared with other modes of travel shows the extreme hazard of flying.

The mortality rate of airplane pilots during the first six months of 1929, in contract mail operations, was one to every 1,063,293 miles flown, according to figures made available by the aeronautics branch of the Department of Commerce. This was a decrease of 50 per cent under the rate for the first half of 1928, a comparison of figures showed.

The number of miles flown by contract mail operations in the first half of 1929 (6,379,776) nearly equals the mileage for the entire year of 1928, when 7,846,296 miles were flown, and seven pilots and nine passengers were killed, the department states. On all other scheduled airway operations in 1928 there were two pilots and four passengers killed out of 2,827,154 miles flown, the data disclosed.

Magazines and newspapers that are trying to belittle the risks involved in flying are not rendering a public service. Quite the contrary; for the sooner the public wakes up to the real danger of this mode of travel, the greater will be the progress toward rendering it reasonably safe.

The Cost of Operating an Automobile

According to figures compiled by the American Motorists Association the cost of operating the average passenger automobile is $418 annually to which we may add $52 for interest, or a total of $470, distributed thus:

Interest, 6%×$875	$ 52
Depreciation, 1/7×$875	125
Gasoline, oil and grease	101
Repairs, parts	55
Repairs, labor	82
Tires	34
Accessories	21
Total	$470

This does not include garage rental.

The $875 is the average retail price of passenger cars in America in 1928. The life of 7 years is said to be based on a Government estimate.

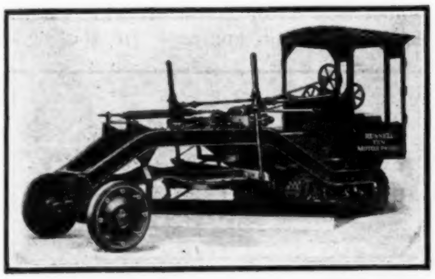
When objection is raised to a gasoline tax, it is well to have in mind the total cost above given. A tax of 3 ct. a gallon sounds big until it is reduced to dollars per annum and compared with the total annual cost of $470, when it is seen to be less than 3 per cent of that total.

It is interesting to note that repairs and depreciation total $262 annually, or nearly 30 per cent of the first cost of the average car. On this basis, it would pay to trade in a car at the end of its first year if the trade-in value were 70 per cent of its new value, and assuming that the repairs are nominal during the first year of service. Not a few car owners have adopted such a policy, reasoning that the improvements on new cars plus the securing of a new set of tires and the freedom from "car troubles" warrant accepting the prevailing discounts on cars a year old.

H P Gillette

Caterpillar Ten and Fifteen Motor Patrols

The fruits of the Caterpillar-Russell merger are fast becoming apparent with the appearance of a power-take-off elevating grader, improvements in the regular blade graders, and now the new Ten and Fifteen motor patrols. Building road equipment to fit definite power plants, made possible by the merger, is resulting in improved and simplified machines to fit every job.



New Caterpillar-Russell Ten Motor Patrol

The new motor patrols are simpler in construction. Many wearing parts have been eliminated. The blade lift is more powerful. The entire mechanism is easily controlled from the driver's seat by means of four easy turning wheels. Many older models had as many as fifteen controls.

The new feature of the Ten and Fifteen motor patrols are:

1. The blade lifting mechanism consists of a machine-cut round steel screw, which is connected to the circle crossbar by a large ball and socket. Take-up shims are provided for wear. The screw is operated by a long bronze nut mounted between ball bearings. The nut operates by a set of steel machine-cut bevel gears. There is a take-up for the ball bearings which take both the up and down thrust. The entire screw and gear mechanism is enclosed in dustproof housing.

The advantages are: Larger wearing surface, simplicity, greater leverage, wearing parts reduced, lessened danger of breakage, greater rigidity, weight off tractor, far easier operation.

2. Just four easy turning wheels, as operating controls squarely in front of the operator, give complete command of the machine at all times. Top-steering wheel operates easy-turning, steel-cut worm and gear steering control. Left and right screw blade-lift wheels and bottom-side shift and scarifier wheel (operating through single gear box) and wheels mentioned.

3. By merely pulling out or pushing in a steel plug and wheel, gears are shifted in the gear box to operate the side shift and scarifier from the same wheel.

4. The draft connection on the Ten is a tight connection with a large wearing surface ball and socket which eliminates play, yet gives utmost freedom to pivot in any direction. The Fifteen connection is the same as the Twenty.

5. The tractor connection is flexible with strain eliminated. The tractor and grader frame connection is mounted in self-aligning bearings (its function similar to ball and socket) with the trunion shaft centrally located on the tracks. This mechanism gives free movement without binding or bending strain upon either tracks or grader frame.

New Concrete Delivery Tank Announced

Another new type of mixed concrete transporting tank has made its appearance. R M C concrete delivery tanks are rotated by a separate engine. Special vanes attached to the inside of the drum prevents separation of cement and water from the mass, and assists in producing a more uniform consistency of mix.

The tank is hermetically sealed; no loss occurring by evaporation or leakage during transportation. It is built in four sizes of 2, 3, 4 and 5 cu. yd. capacities.

It is a complete assembled unit consisting of a cylindrical steel tank mounted on a heavy steel underframe and supported at each end by large trunnion shafts revolving in self-aligning roller bearings. It can be mounted on any standard truck chassis.

The tank is revolved by means of cut steel pinion engaging gear segments attached to the outer circumference of the tank at the front end. Power is furnished by LeRoi 2-cyl. engine by means of a chain drive from sprocket on gearshaft to sprocket on pinion shaft.

A discharge door at the bottom of the drum is operated by a rack and pinion actuated by a hand crank. An adjustable chute is provided, to which portable chutes may be attached.

The Portland Concrete Machines Co., 53 W. Jackson Blvd., Chicago, will be glad to send additional information on request.

New R M C Concrete Delivery Tank

New Multi-Power Clamshell Bucket

The Erie Steel Construction Company of Erie, Penna., has designed a powerful digging bucket that can be adjusted for the kind of material being dug.

The new bucket is named Multi-Power from its working action, which

Erie Steel Company's New Clamshell Bucket

is a combination of two well known principles, namely: The multiple rope and lever arm principles. The multiple rope principle gives power, but slows up the action of the bucket. The lever arm principle gives speed as well as power. Combining the two you have a better digger and a faster bucket than with either one alone.

This new bucket can be rigged up with 2, 3, 4, 5, or 6 parts of line. In combining the two principles they were able to design a bucket requiring considerable less head room, and by having less head room there is less line to overhaul. This also speeds up operation of the bucket.

The scoops are oversize with but very little added bucket weight. Thus more material can be handled per day with little added power consumption.

Counterweights in 100 lb. units can be added by one man. They are attached to the buckets by two bolts and

can be put on or taken off in but a few minutes.

In addition to these major features there are others which are very important. The stops are improved, relocated, and longer—so designed to add reinforcement to the power arm. The main bearing is wider and will take the shock of digging more smoothly and eliminate excessive wear.

All ropes end in wedge and socket. Roller bearings can be furnished in the power arm sheaves at no extra cost. Stellite can be applied to the lips at a slight additional cost. Teeth are of the self-burying chisel point type and pull the bucket down into the material while closing.

Sheaves are of steel and are kept clean by special sheave cleaners. Large bearings keep the parts in alignment. There are heavy down thrust lugs on the bucket scoops to relieve the rivets. The down thrust is actually on the edge of the bucket—thus forcing the scoops into the materials while closing instead of lifting out.

Lubrication is by the Alemite system, and a grease gun is furnished with each bucket. They claim the bucket has been on test since the first of the year.

The bucket was tested in natural earth excavating of blue clay, shale rock, muck, gravel, quick sand, sod, roots, rocks, etc., and also in rehandling crushed stone, limestone, coal, coke, sulphur, etc. It was tested for days under water with no apparent effect.

New Trailing Scraper Announced

The Miami Tractor-Scraper Co. of Troy, Ohio, announced the development of a new scraper for use with small crawler type tractors. The Miami is mounted on high roller bearing wheels and is operated by a winch on the rear of the tractor. It can be backed up against a wall or over the edge of an embankment and the load dumped while the unit is stationary. The load can also be dumped while the unit is moving forward or in reverse.

Because of the winch control the scoop bowl can be raised or lowered as desired.

New Miami Scraper

Foote Announces New Water Control for Pavers

To meet the increasingly rigid requirements of highway departments for accurate water measurements on paving, concrete engineers of the Foote Co., Inc., of Nunda, N. Y., manufacturers of Multi-Foote pavers, after many experiments and tests, have developed a water tank construction on an entirely new principle which effects accurate control of water to the smallest fraction of a gallon under all conditions and which combines several other important advantages.

The new tank is of the vertical cylindrical type with a capacity of 46 gal. and can be set so that it automatically measures any desired quantity of water in pounds or gallons by a simple turn of an adjusting crank. The tank fills itself automatically and signals the operator when it is full, the control system being arranged so that the supply valve through which the tank is filled always closes in advance of the discharge valve which connects to the mixer drum through a 3½-in. line and which permits quick discharge of water. Vice versa the discharge valve closes automatically before the supply valve can be opened, thus eliminating all possibility of putting into the drum more or less water than is needed.

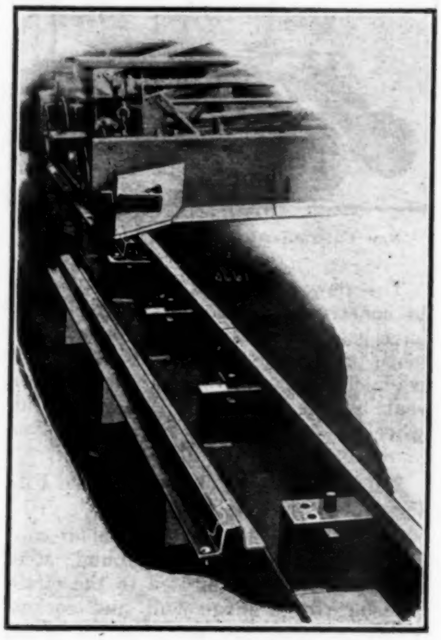
The tank contains a piston, in the head of which is a simple automatic valve which permits the air to escape when water enters the portion of the tank underneath the piston. The piston is adjustable to a graduated scale so that it can be set to measure any desired quantity of water in either gallons or pounds. When the portion of the cylinder below the piston is completely filled with water the air valve in the piston head closes and the resulting pressure automatically closes the water supply valve before more than 5 lb. pressure has been built up on the tank.

Some of the special advantages claimed for this new tank are as follows:

1. The tank is completely drained at each operation.
2. Tilting of the tank due to conditions of grade do not affect the measurement.
3. The pressure on the tank never exceeds five pounds regardless of the pressure on the supply line.
4. The supply valve is always closed before the discharge valve opens and vice versa, preventing bi-passing of water during the valve shifting operation.
5. Automatic closing of the supply valve and signaling of the operator when the tank is full.
6. Ease and fine accuracy of adjustment either in pounds or fractions of a gallon.
7. Low clearance for shipping or moving under low overhead obstructions without removing the tank from paver.
8. Simplicity of tank construction and valve operation.
9. Excessive air pocketed in supply line cannot pocket in tank and interfere with accurate measurement.
10. Protection against excessive pressure by special relief valve.

Lakewood "Duo-Rail" Form Developed

The new Lakewood Duo-Rail form has been devised to accomplish that which will be of material value to the contractor and engineer in the continued effort to get a smoother riding surface on concrete roads.



Showing How New Lakewood Duo-Rail Is Employed

The novel construction of this form lies in the fact that the load of the finishing machine is carried over the center of the base of the form by means of an auxiliary rail, thus materially adding to the stability and bearing value of the form.

These rails are held in place on the stake pockets by dowel pins fastened thereto, fitting into the holes in the stake pockets, and approximately 100 feet of the auxiliary rail is all that is used on each side of the road for finishing machine operation, being carried forward as the work progresses.

The base of this form is 8 in. wide, and therefore due to this additional width and central loading, offers considerably more value than the present standard 6-in. base form, with the load carried on the inside web.

The auxiliary rail is used only for the finishing machine, the floatbridges and other lighter equipment being carried as usual on the form proper, which also acts as the template for the screed member of the finishing machine.